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REPORT ON
THE BED-BUG

MINISTRY OF HEALTH

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REPORT OF COMMITTEE
ON
THE ERADICATION OF BED-BUGS

THE RT. HON. SIR HILTON YOUNG, G.B.E., D.S.O., D.S.C., M.P.,
Minister of Health.

SIR,

During recent years occasional representations have been made to the Ministry of Health by Local Authorities as to the spread of infestation by Bed-bugs. The problem has lately become more acute in consequence of increased activity in the work of dealing with unhealthy areas and insanitary houses. A large number of tenants of council houses are now being drawn from verminous dwellings, and the infestation of new council houses has become a matter of concern to the Local Authorities who are responsible for their maintenance and management.

A small committee with your approval was therefore set up in August of this year consisting of :—

Dr. G. W. Monier-Williams, O.B.E., M.C., Ph.D., F.I.C., Ministry of Health (Chairman).

Major-General P. H. Henderson, D.S.O., K.H.P., M.B., War Office.

Mr. C. R. Kerwood, Ministry of Health.

Mr. A. W. McKenny Hughes, D.I.C., F.R.E.S., British Museum (Natural History).

Mr. D. Morrell, H.M. Office of Works.

Dr. P. G. Stock, C.B., C.B.E., Hon. F.R.C.S.(Ed.), M.B., M.R.C.P., Ministry of Health (Secretary).

with instructions to review the position and, if necessary, to submit proposals for further experimental work with a view to devising a satisfactory method which could safely be recommended to Local Authorities for the eradication of Bed-bugs.

The Committee has held eight meetings and has received reports from Local Authorities and others concerned in the matter. Discussions have taken place with various experts who have specially studied the problem and several promising lines of inquiry have been followed up. Individual members have visited some of the Metropolitan Boroughs, and also Manchester, Leeds, Glasgow and Edinburgh, to investigate on the spot various aspects of the problem. A large amount of work has been done in the Laboratory of the Ministry of Health on the composition of proprietary insecticides (Appendix I) and a summary has been prepared of the more important literature on the subject of Bed-bugs (Appendix III).

It appeared to the Committee advisable, in view of the urgency of the problem, that a report should be presented at an early date

summarising the present position, indicating the directions in which future work on the problem might most profitably be undertaken, and giving some guidance on the steps to be taken for dealing with Bed-bugs.

1. The extent of Bed-bug Infestation in this Country.

As a result of a questionnaire addressed to the London County Council, the Councils of the City of London and of the Metropolitan and County Boroughs, it has been possible to form some opinion as to the extent of the problem. Estimates of the amount of infestation of houses provided under the various Housing Acts since that of 1919 vary greatly, some estimates being in the neighbourhood of 50 per cent.

Virtually every urban authority is more or less troubled with this problem. It is estimated that in many areas practically all the houses are to a greater or less degree infested with Bed-bugs.

It is difficult to obtain evidence as to whether or not the Bed-bug population has actually increased in recent years. It has been suggested that the unusually hot weather of the past two years has had some effect in increasing the total amount of infestation. Whilst this is possible, we have had no actual evidence that the recent hot summers have been an important factor. The fact that the question of infestation by Bed-bugs has come into greater prominence recently is no doubt due largely to the greater attention which is now being paid to insanitary working-class houses. The removal of tenants of old and insanitary bug-infested houses to council houses with their modern conveniences and the spread of general education and knowledge of the value of cleanliness have stimulated the desire among tenants to rid their dwellings of Bed-bugs, and the infestation of council houses has certainly focussed the attention of Local Authorities on the subject. A Local Authority is bound, as landlord, to maintain a high standard of cleanliness in its houses, and the discovery that one of the evils which slum clearance schemes are designed to remove has spread to the new housing estates is distinctly disquieting.

Quite apart from slum clearance schemes, an increasing amount of effort has been directed during the 15 years that have elapsed since the war towards improving the health and conditions of life of the poorer sections of the community, and the question of vermin and its eradication has come more and more into prominence.

The view is sometimes expressed that Bed-bugs are one of the factors that create slums and that, when once they have obtained a foothold in an area, that area tends to become populated more and more by families who tolerate Bed-bugs and have acquired a certain degree of immunity towards them. To some extent this may be true, but we are convinced that by far the greater number of dwellers in infested houses suffer acutely from the presence of Bed-bugs and are genuinely anxious to get rid of them.

2. Bed-bugs in relation to Public Health.

Bed-bugs have not been definitely convicted of carrying disease. It is possible that in certain circumstances they may carry infection from one person to another, but there is no evidence that they are active agents in the dissemination of any particular pathogenic organism in the way that fleas carry plague, lice typhus fever, or mosquitoes malaria.

It may be that Bed-bugs are responsible for actual ill-health from lack of sleep due to skin irritation. It has been suggested that in groups of school-children it is possible to pick out those that come from bug-infested houses by their sallow complexions and listless appearance. Obviously it is difficult here to correlate cause and effect. The presence of Bed-bugs may well be a result of conditions in the house which make for ill-health and not primarily a cause of ill-health.

3. The Life History and Habits of the Bed-bug.

The adult Bed-bug (*Cimex lectularius* Linn.) is a flat, oval, wingless creature with three pairs of legs. Beneath the head is the beak or rostrum containing the organs for piercing and sucking. Under natural conditions the Bed-bug feeds only upon blood. It is generally nocturnal in habit, feeding mostly at night and hiding in the daytime, but occasionally Bed-bugs may be seen at any time of the day or night in warm rooms in infested dwellings. The colour of the two sexes is the same—dark chestnut or mahogany brown. After feeding the abdomen becomes extended and domed, darker in colour, and the segments are more clearly distinguishable. The eyes are black. The respiratory system consists of a number of air tubes leading directly to different parts of the body and opening by a series of apertures, or spiracles, on both sides. The life of the adult Bed-bug varies from a few weeks up to four years or more, according to food supply available, temperature, humidity and other considerations.

At the normal temperature in this country the Bed-bug seldom feeds more than once a week, and is capable of existing for six months or more without food. After such fasts it is almost as thin as a piece of paper and much more transparent than when regularly fed. A well-fed Bed-bug is more fertile than one which has fasted for some time, and a female fertilised by a well-fed male is said to be more prolific. The Bed-bug seems to be more vulnerable when it is fed than when it is starved, but further experimental work is necessary with regard to this point and to the relative resistance at the different stages of growth under varying conditions.

Bed-bugs are more active in hot weather but temperatures over 113° F. are said to be lethal. There is evidence that Bed-bugs are attracted to warm surfaces and also by smell or a combination of heat and smell, but so far as we know such attraction extends only up to short distances of less than two inches.

They can travel considerable distances in search of food and are said to be quite capable of moving from one house to the next to feed and then of returning to the original hiding place. Under experimental conditions the Bed-bug has been fed and propagated on the blood of such animals as rats, mice, guinea pigs, rabbits, fowls, etc., and under natural conditions where there are records of great longevity without contact with human beings it is possible that rats, mice or sparrows may have been the source of the food supply. Both the young Bed-bugs, or nymphs, and the adult insects have "stink glands" which emit a peculiar musty smell by which the presence of Bed-bugs can often be detected when the insects themselves are not seen.

Eggs.—Under normal conditions a female Bed-bug will lay two or three eggs a day and during her lifetime may lay from 100 to 200 eggs. These may be laid at irregular intervals and the laying of each batch of fertile eggs is nearly always preceded by a meal. Thus a Bed-bug living for a long time may have several periods of laying.

Eggs are laid singly or in batches in the crevices of bedsteads, on mattresses, behind wallpaper, skirtings and architraves, and in similar situations.

The eggs are small yellowish-white objects about 1/20th of an inch long and about 1/60th of an inch broad. They taper somewhat towards the top and may be slightly curved. At the apex is a collar, and a lid which the young insect pushes up in the process of hatching. A form of quick-drying cement is exuded at the time of laying by which the eggs are attached to the surface on which they are laid. Before hatching the red eye of the enclosed insect can be seen distinctly with the aid of a hand lens. When the egg has hatched the shell is white and iridescent and the lid usually has disappeared.

The eggs hatch in from one to three weeks, but this period may be considerably prolonged; further research is necessary on this point.

Nymphs.—When the egg hatches a pale straw-coloured semi-transparent insect emerges which resembles the adult, though it is smaller and paler in colour, and the antennæ are stouter, the eyes are red, and the body is less flat. If food is available the young Bed-bug may feed at once though it can exist for two or three months without food. Five or possibly six moults take place before the insect is mature, and feeding is necessary between each moult. After each moult the young Bed-bug becomes larger and darker in colour. It is common to find the cast skins clustered together in the harbourages. The time elapsing from egg to adult may under most favourable conditions be as short as six weeks, but the probable average period in this country is about 10 weeks; scarcity of food and other unfavourable circumstances may prolong the period to a year or even longer.

It should be noted, however, that various factors such as climate, food supply, and habitat may cause the period of development of any stage in the life history (egg, nymph or adult) to vary enormously.

4. The Control of Bed-bug Infestation.

It should be recognised that there are several distinct and separate problems which present themselves for solution when dealing with Bed-bug infestation which, broadly speaking, may be grouped under (A) the prevention of dissemination of Bed-bugs, (B) the destruction of Bed-bugs in inhabited and in empty houses, and (C) the elimination of Bed-bug harbourages in new houses.

Dissemination may be caused by :—

(i) Transfer of infested furniture and bedding.
(ii) Removal of furniture and bedding in infested vans.
(iii) Trade in second-hand furniture and bedding.
(iv) Migration of Bed-bugs from house to house.
(v) Use of old materials, more especially wood.

From the evidence before us it does not appear that human beings or their clothing are important factors in the general dissemination of Bed-bugs in this country.

While the broad principles of control remain the same in all these various aspects of the problem, the actual methods used vary greatly according to the circumstances of the case.

A. Prevention of Dissemination of Bed-bugs.

(i) *Transfer of Infested Furniture.*

From our inquiries and investigations so far carried out it would appear that the removal of furniture and bedding from infested houses to new houses is by far the most potent factor in the dissemination of Bed-bugs. It must be admitted that very large numbers of families have already been moved from condemned houses into new quarters without any adequate attempts having been made to clean or disinfest their furniture or even their bedding. During the course of an experimental fumigation at Manchester it was found that hundreds of Bed-bugs and their eggs were ensconced in the folds at the top of a pair of curtains. If these curtains had been rehung without thorough cleaning, the new house would rapidly have become just as badly infested as the old one.

In an extremely valuable report issued by the Department of Health for Scotland, Dr. W. C. Gunn, the Senior Assistant Medical Officer of Glasgow, details the methods adopted in Glasgow to prevent transference of Bed-bugs from house to house. In the main they consist in visiting and educating the tenants in the practice of household cleanliness, particularly the thorough scrubbing and cleaning of all articles with soap and water by the tenants themselves under supervision. Bedding is treated by the usual method of steam disinfection. The report throughout is insistent on the

importance of adopting the ordinary methods of spring-cleaning combined with knowledge of the habits of the Bed-bug, so that all possible harbourages may be recognised and dealt with. Contact insecticides and fumigation are accepted as useful aids in certain cases, but never as substitutes for soap and water and general cleanliness. It is claimed that these methods have been quite effective in preventing reinfestation. Some further details of the Glasgow system of inspection and supervision are given in Appendix II.

Clearly, however, cleansing with soap and water and the use of contact insecticides will not destroy Bed-bugs or their eggs in upholstered furniture, and in the opinion of many authorities the only effective method is fumigation. In Manchester several experiments have been carried out at the instance of the Council on the fumigation of furniture in vans. Whilst the family were taken to the cleansing station, where they were bathed and their clothes passed through the steam disinfector, the contents of the house were loaded into ordinary furniture vans and driven to an open yard. Hydrogen cyanide was introduced into the van so as to produce a high concentration—2 per cent., or more, by volume—and the van was sealed up. In two of the experiments the gas was generated from liquid hydrogen cyanide in a porous absorbent and in the other from sodium cyanide and sulphuric acid. Tests on live Bed-bugs protected in various ways from direct exposure to gas were satisfactory. The period of exposure to gas was about three hours and the subsequent removal of gas from the vans and furniture by ventilation presented no great difficulty except in the case of bedding. The bedding after fumigation and subsequent exposure to air still contained dangerous amounts of hydrogen cyanide. It was therefore placed in a Washington-Lyons steam disinfecting machine and subjected to alternate treatment with hot air and vacuum for a period of about 1½ hours. It was then removed and beaten in the open air for a short time. When the fumigation had been carried out with cyanide and acid, treatment with hot air and vacuum failed to remove the gas satisfactorily. When the gas used was generated from liquid hydrogen cyanide in a porous absorbent, removal of residual gas from the bedding was satisfactorily accomplished Possibly the deciding factor was the amount of moisture in the gas, which is greater in the gas generated from cyanide and acid than in the gas from liquid hydrogen cyanide. Further experiments are to be carried out to settle this point.

It is obviously of great importance, when many families are being moved on the same day, that their furniture and bedding can be certified absolutely safe and free from gas on the same evening and moved into the new house, otherwise it is necessary to provide temporary accommodation or make provision for the loan of bedding and the storage of furniture overnight. The Manchester

experiments are extremely promising and may go far towards solving the problems of infested furniture.

The Leeds City Council have been in consultation with representatives of Imperial Chemical Industries, Ltd., with a view to the installation of a cyanide fumigating plant in which furniture will be fumigated in specially constructed vans. It is hoped to have the installation at work in a few months' time. At present it is not contemplated that bedding will be fumigated but that it will be dealt with separately in steam disinfectors.

We are informed that " Cyanogas " (calcium cyanide) has been used successfully for fumigating furniture in vans.

Pending the completion of further experimental work on these lines it is difficult to give a definite opinion as to the extent to which fumigation with hydrogen cyanide is capable of practical application.

With some tenants the Glasgow methods, which depend upon the active and intelligent co-operation of the tenants themselves, are probably effective if properly organized and supervised and have the advantage of cheapness. On the other hand, with difficult and unsatisfactory tenants there is little doubt at present that cyanide fumigation is the most effective alternative, and without fumigation it will be a long and laborious process to get rid of Bed-bugs from upholstered furniture.

Absolute reliance, however, should not be placed upon fumigation alone. The great value of the Glasgow report is the emphasis which it lays upon the inculcation in the tenants of sound principles of cleanliness, without which reinfestation will almost certainly occur sooner or later.

(ii) *Removal of Furniture and Bedding in Infested Vans.*

There is reason to believe that some vans used for the removal of furniture become infested with Bed-bugs to a greater or less extent. It is obvious that unless these vans are submitted to disinfestation they may be the means of contaminating clean furniture in transit.

(iii) *Second-hand Furniture.*

It has been suggested to us that second-hand furniture is often a source of infestation and in the Glasgow report it is regarded as an important factor. We have not much evidence on this point, but it is obvious that Bed-bugs may be introduced by this means, and it is a matter that must be kept in mind. Probably the most practical way of reducing this risk is by means of education. Dealers and tenants should be made aware that second-hand furniture may introduce Bed-bugs, and be instructed as to the precautions to be taken.

(iv) *Migration of Bed-bugs from House to House.*

Bed-bugs are popularly credited with an amazing amount of intelligence. It is stated that they will travel long distances,

50 yards or more, nightly, in search of food, will unerringly choose the direction in which their food is to be found, will go by way of windows, eaves and gutters if unable to get through the party wall, and will drop from the ceiling on to their victims. We are not prepared to say how much of this may be due to popular superstition, but it is clear that the habits of the Bed-bug and its powers of migration call for detailed expert investigation if measures for its elimination are to be successfully applied.

(v) *Use of Old Materials for Other Purposes.*

Under this heading the most likely source of Bed-bug infestation is the sale of old timber as firewood. In investigations made by Mr. McKenny Hughes in Woolwich and Stepney it was found that wood from demolished cottages was removed to house-breakers' yards and sold for firewood. In this way wood from an infested source might carry Bed-bugs into a large number of houses. We are endeavouring to arrange that some wood from a badly infested house undergoing demolition should be stored under our supervision, so that we may form some opinion as to the relative danger of this source of infestation. We were informed that when infested buildings are demolished in Glasgow workmen treat all timber with a large blow-lamp, which is considered an efficient and practical method.

There is reason to suppose that old bricks are not likely to convey Bed-bugs, as they are cleaned, *i.e.*, divested of adhering mortar, before being used again.

In general the problem of dissemination by old material is not a serious one if the building has become the property of the Local Authority, since arrangements can be made for the treatment or destruction of the wood from badly infested houses and for expert inspection of all materials before they are sold or re-used.

If the house forms part of an area scheduled under a clearance order, it remains, after vacation, the property of the landlord, and the Local Authority have no control over the disposal of the materials. It would clearly be of advantage if a Local Authority were in a position to secure that infested material was suitably disposed of to their satisfaction.

We have no evidence as to whether Bed-bugs migrate to adjoining buildings when an infested building is demolished, nor whether new buildings subsequently erected on the site are liable to become infested. These are points for further investigation, but we doubt whether any Bed-bugs left on a site could survive the operations involved in re-building.

B.—Destruction of Bed-bugs in Inhabited and in Empty Houses.

For the successful extermination of Bed-bugs in houses knowledge of the insect and of its habits is essential. The information available on this subject is admirably set out in detail in the Scottish Report

already referred to and also in the pamphlet on the Bed-bug issued by the British Museum (Natural History). We propose to refer here only to the salient points.

Bed-bugs like to get in contact with rough surfaces and prefer places which afford warmth, undisturbed conditions and darkness, though the latter is not essential. They may be found behind picture rails and skirting boards, behind wall-paper, in cracks in plaster walls and ceilings, in nail holes, in spaces where wood has shrunk away from plaster, behind pictures and inside the paper backing where torn, in the ends of spring mattresses, under the screw knobs of metal bedsteads, in boxes and trunks which have lain undisturbed for some time, under floor boards, etc. The measures adopted must be designed to deal with all these types of harbourage.

(i) *Fumigation.*

Hydrogen cyanide is probably the most efficient fumigant that is known for the destruction of Bed-bugs, and the method is extensively employed in the United States and South Africa. In this country the danger of accidents has restricted its use for inhabited houses, but from time to time it has been used with a fair measure of success.

Recently, hydrogen cyanide has been used to fumigate dwellings which have become infested on the new housing estates of the London County Council, and we are informed that some hundreds of houses have been dealt with and that the results have been uniformly satisfactory. Houses have also been successfully fumigated by this method on other housing estates.

We desire to emphasise the necessity for the greatest care if accidents are to be avoided. Fumigation with hydrogen cyanide should only be undertaken by responsible persons with full knowledge of the nature of the gas and of the precautions which must be observed. A house must be kept vacant until it is certified free from gas, and if it is not completely detached, the houses on each side must also be kept vacant for about eight hours and kept under observation by trained men to detect possible leakage of the fumigant. In cold weather dissipation of the gas is slow and repeated tests may be necessary before a dwelling, and particularly the sleeping rooms, can be declared free from gas. In such circumstances it may be necessary to close and warm the rooms and to apply tests again for the presence of gas. Special attention must be paid to the possibility of gas lingering in bedding, blankets, pillows, stuffed furniture, etc., which should be beaten in the open air before they are allowed to be used.

We understand that at present there is no statutory power to make regulations for the control of fumigation with cyanide or other poisonous gases.

Fumigation with *sulphur dioxide* is frequently resorted to and is stated by some authorities to be effective. Dr. Gunn recommends

liquid sulphur dioxide liberated from small cylinders each containing 20 fluid ounces, and employs a concentration of 60–80 fluid ounces per 1,000 cubic feet, giving a nominal concentration of 1 in 140. It has been found advantageous to begin the disinfestation process by spraying with a 1 in 20 solution of cyllin as the gas seems to be more effective if the atmosphere is moist and warm. Fumigation by the ordinary method of burning sulphur is practised by several Local Authorities. The gas thus generated is possibly more toxic than that produced by the evaporation of liquid sulphur dioxide, owing to the admixture of a certain amount of sulphur trioxide. It has the disadvantage, however, of adversely affecting fabrics, metals, etc., especially in presence of moisture. When possible, fumigation of a house should be repeated after three weeks, in order that any larvæ, hatched in the interval from the eggs which have survived the first fumigation, may be destroyed.

Of other fumigants there are only two that have been used to any considerable extent, formaldehyde and ethylene oxide. Fumigation with *formaldehyde* is laid down as a standard method in the Regulations for the Medical Services of the Army. The vapour is generated by the heat of reaction between formalin and bleaching powder. Two pints of formalin and two pounds of chloride of lime are required for every 1,000 cubic feet. Further details of this method are given in the pamphlet on the Bed-bug issued by the British Museum (Natural History) already referred to. It is stated that it is effective and safe for disinfestation of small rooms.

Ethylene oxide has been used fairly extensively in the United States, preferably mixed with carbon dioxide, for killing all kinds of vermin in grain and other foodstuffs. It has the great advantage of being less toxic to man than hydrogen cyanide, and whilst it is also less toxic to Bed-bugs it is an efficient fumigant under favourable conditions. The gas, however, must be used in comparatively heavy concentrations, and the exposure must be prolonged, usually for about 24 hours. It appears to have greater penetrating powers than hydrogen cyanide. Occasionally on opening up a room after fumigation, no trace of the gas remains, but in other cases the concentration is almost unimpaired ; why this should be so is not clear. It is stated that ethylene oxide cannot be used effectively at a temperature below 55° F., and unless mixed with carbon dioxide there is considerable risk of fire. At present it is an expensive method of fumigation, but it may well prove to possess advantages over other more laborious methods. We think that further work should be carried out on the effect of ethylene oxide on Bed-bugs. It is possible that it may be found of great value in the fumigation of inhabited houses and that the cost would be reduced if there were any considerable demand for it in this country.

(ii) *Contact Insecticides and Sprays.*

A large number of proprietary articles are sold under various names, with claims that they are infallible toxic agents for Bed-bugs. Thirty-five different proprietary preparations used by Local Authorities throughout the country have been collected and examined in the Ministry's laboratory. The results are given in Appendix I.

It will be seen that in most cases commercial insecticides consist of paraffin containing a small percentage of one or more of the following ingredients: Phenols, chlorinated hydrocarbons such as dichlor-benzene, nitrobenzene, formaldehyde, methyl salicylate (oil of wintergreen), salicylic acid, pyrethrum extract, derris extract and essential oils (citronella, heliotrope, cedarwood oil, vanilla, etc.). A few are similar to the ordinary type of coal tar disinfectants, such as lysol. It is claimed for some of these mixtures that they give off a vapour which is toxic to Bed-bugs, and for others that the vapour is sufficiently irritating to induce them to leave their harbourages and come into the open where they may be sprayed directly.

It is a relatively easy matter to devise a mixture of chemicals which will kill Bed-bugs when sprayed directly on to them. If insecticides are capable of nothing more than this, there is ample justification for the view expressed by Dr. Gunn that they are in no wise superior in efficacy to soap and water. There is reason to believe, however, that some of these mixtures may in fact compel or induce Bed-bugs to leave their harbourages and expose themselves to the direct action of the spray. Mr. McKenny Hughes was able to confirm this in an experiment at Woolwich with ortho-dichlor-benzene, and it is possible that phenol vapour, to which Bed-bugs appear to be highly sensitive, may have a similar effect.

Very little is known of the relative toxicity to Bed-bugs of different chemical substances. We think that a comprehensive investigation should be undertaken with the object of ascertaining what substances are definitely toxic to Bed-bugs under different conditions and what is the best way to apply them, whether as washes, sprays or vapour, the best types of solvent or vehicle to use, and the most efficient patterns of sprayers. Accurate information on this subject would save considerable expenditure on high-priced proprietary articles of doubtful efficacy.

By H.M. Office of Works a liquid insecticide is used, consisting of:

Paraffin oil	50 gallons
Ortho-dichlor-benzene	2 gallons
Methyl salicylate.	1 gallon

The results obtained by the use of this preparation have been satisfactory.

Similarly in the Army, the following mixture has been used successfully :—

Paraffin oil (B.Pt. 170° C. to 240° C.)	...	1,000 parts.
Oil of mirbane (nitro-benzene)...	... ...	2 parts.
Cresol	...	2 parts.
Pyrethrum flowers (ground) ...	... ...	10 parts.

The pyrethrum is soaked in the liquid for 24 hours and the mixture then filtered clear.

These preparations have the advantage of being cheap.

(iii) *Miscellaneous methods.*

Bed-bugs are killed if exposed for a short time to a temperature of 120° F., and it has been proposed to make practical use of this fact in the disinfestation of houses. Most of this work emanates from Canada and the United States. There are many difficulties in the way of raising the temperature sufficiently in the interior of walls, cracks in wood and plaster, etc., and it is doubtful whether it could be done in this country, except in rare spells of very hot weather. On a small scale, heat, applied locally by a blow-lamp, is a valuable aid to other methods of Bed-bug destruction, and steam has also been used with success.

The subject of deterrents is one that merits further investigation. An ideal deterrent must not possess an objectionable smell, must not be actively toxic to man, and must retain its deterrent properties for a long period. Preparations of mercury, creosote, etc., have been tried and found efficacious in certain cases, and in ships' forecastles anti-fouling paint containing copper compounds has been used successfully, but does not appear to retain its deterrent properties for long. Sodium silicofluoride is effective for cockroaches, but we have no information as to its efficacy against Bed-bugs. It is possible that systematic investigation might reveal substances that can be incorporated in structural work and exert a permanent deterrent effect on Bed-bugs. In this connection, reference may be made to the deterrent action of magnesium oxychloride. Plaster containing this substance is claimed to be strongly deterrent, if not actually toxic to Bed-bugs. These claims should be investigated. In particular, further information is required as to—

(i) Its suitability as a plastering material ;
(ii) Whether it will retain its deterrent properties indefinitely ;
(iii) Its cost in relation to the type of plaster normally used ; and
(iv) Its effect on other materials, such as iron pipes, with which it may come into contact.

In the biological field an interesting experiment may be mentioned which was recently carried out at Gibraltar by Major G. D. Jameson, R.A.M.C. A nest of ants (*Monomorium pharaonis*) was placed in the

ceiling of an infested room and the ants were observed attacking the Bed-bugs and taking them to their nest. The Bed-bugs rapidly decreased and the subsequent disappearance of the ants was attributed to the fact that the Bed-bug population was so diminished as no longer to afford a sufficient food supply to the ant colony. In a subsequent experiment the ants rapidly disappeared, and to ensure success it seems essential that a complete nest should be transferred if the ants are to remain in the site selected for any length of time.

C. The Elimination of Bed-bug Harbourages in New Houses.

We think that in the designing of new houses much could be done in the direction of eliminating harbourages and rendering disinfestation a far simpler matter with the minimum of structural disturbance.

Harbourages may be classified as due (*a*) to the methods of construction employed and (*b*) to weakness or defects in the structure itself.

(*a*) *Harbourages Due to the Methods of Construction.*

The chief harbourages under this heading and the ways in which they can be eliminated are as follows :—

(i) *Ceilings and partitions.*—Wall boards with wood cover fillets over the joints afford a most effective harbourage for Bed-bugs in the space between the fillets and the boards.

(ii) *Wall decoration.*—A distemper or paint finish to walls is suggested in lieu of wallpaper.

(iii) *Picture rails.*—Should be eliminated wherever possible, especially in bedrooms. In living-rooms a metal rail, with a wide rather than narrow groove, embedded in the plaster might be used instead of a wood rail. Alternatively small dovetailed wood plugs might be fixed flush with the plaster in suitable positions to take heavy pictures. For light pictures a thin wire nail is all that is required and this need do no damage to the plaster.

(iv) *Skirtings.*—Wood skirtings might be eliminated. A skirting of cement plaster with a one-inch cover mould nailed to the floor boards at the junction of skirting and floor is a suitable alternative. A cover mould of the kind suggested is easily removed and re-fixed if this should become necessary.

(v) *Architraves.*—Wood architraves might be eliminated. To cover the crack which is bound to develop between frame and plaster some Local Authorities have employed a strip of linen tape about three inches wide, which, if painted, has the appearance of an architrave and is less liable to become detached.

In the case of windows, the cracks which are liable to occur with wood frames may be avoided by the use of metal frames.

(vi) *Window boards.*—Wood might be avoided for this purpose. Quarry tiles are a suitable alternative.

(vii) *Floors.*—The only types of flooring that can be regarded as "bug-proof" are solid floors such as asphalt, tiles or granolithic laid on concrete. In certain circumstances this method of construction would be appropriate.

(viii) *Built-in fittings.*—Fittings such as dressers, cupboards, shelving, hat and coat rails, mantelpieces, all provide harbourages for Bed-bugs which it does not seem possible to eliminate. The most that can be done is to make these fittings readily removable so that they may be disinfested in the same way as furniture, and the spaces behind them cleaned.

(ix) *Plumbing.*—The back boards necessary with lead pipes provide a good harbourage for Bed-bugs. This could be eliminated by the use of copper or iron pipes fixed well clear of the wall, wherever acceptable to the water authority.

(*b*) *Harbourages Due to Structural Weaknesses or Defects.*

We are advised that in the normal subsidised cottage much of the cracking that is due to the carrying of first floor partitions on wood joists could be prevented, and that the substitution of hollow blocks of fire-clay for the blocks of light concrete generally used for partitions would minimise cracking due to shrinkage in the partitions themselves.

It has been suggested that special "non-cracking" plaster might be used but there appears to be no plaster that will resist without cracking movement in the material to which it is attached.

5. Powers of Local Authorities.

Under the London County Council (General Powers) Act, 1922, and other local Acts, powers were obtained enabling the Local Authorities concerned to take action to deal with verminous premises, etc. In 1925 a code of provisions based on those mentioned above was included in Part IV of the Public Health Act, 1925, which may be adopted by any urban or rural authority. Part IV of the Public Health Act, 1925, enables a Local Authority—

(*a*) To cause any articles in any premises used for human habitation which are infested with vermin or are likely to be infested with vermin to be cleansed, disinfected or destroyed. Compensation is payable in respect of damage sustained by the exercise of these powers where the condition of the article dealt with is not attributable to the act or default of the person sustaining damage.

(*b*) To require the cleansing of any premises used for human habitation which are infested with vermin. Notice is served

on the occupier or on the owner where the work required is work for which the owner is under the tenancy responsible. In case of default the local authority may themselves carry out the work and recover the reasonable costs and expenses.

(c) To provide cleansing stations, apparatus and attendants.

When cleansing is undertaken the local authority may often find occasion to require under their statutory powers the execution of repairs which will be a material factor in preventing re-infestation.

6. Education.

In the report published by the Department of Health for Scotland, reference is made to the training of the sanitary staff and the education and encouragement of the tenant. Too much stress cannot be laid upon these two aspects of the question. It is essential that medical officers, sanitary inspectors, health visitors, etc., should be thoroughly versed in the recognition of Bed-bugs in all their stages and in the salient facts of their life history. It may be necessary for each Local Authority or for a group of Authorities to arrange for special lectures and demonstrations adapted to particular local conditions.

Education of tenants on similar lines and instruction in elementary practical methods of maintaining their furniture and houses free from Bed-bugs is of hardly less importance. To this end it is essential that the staff of the Local Authority engaged on this work should be able to obtain the good will and the confidence of the tenants. We are inclined to think that the success in Glasgow is due in no small measure to the personality and enthusiasm of Dr. Gunn and the other members of Dr. Macgregor's staff.

The responsibility of the Local Authority as landlord and as guardian of the Public Health should not end with the fumigation of furniture and disinfestation of bedding on removal to the new house. Sustained effort is necessary to prevent reinfestation, and a judicious use of educational propaganda will undoubtedly contribute more than any other measure towards a solution of the problem.

It is essential that there should be the closest co-operation between all committees and officers of Local Authorities dealing with the different aspects of housing and slum clearance to secure co-ordinated effort in the elimination of Bed-bugs.

7. Research on Bionomics of Bed-bugs.

In the course of our inquiries we have been struck with the extreme paucity of information on many important points in the physiology and life history of the Bed-bug. Experience has shown that no insect pest has been successfully combatted until its complete life history and reactions to environment have been worked out. In particular, information is urgently wanted upon the effect of

climatic factors upon Bed-bugs. There are general indications that they are more susceptible to starvation in summer than in winter. It also appears probable that breeding is only possible at relatively high temperatures, and that atmospheric humidity exercises considerable influence upon the biology of the insects. On such matters we need precise information which does not exist at present. With it we need facts about the climatic conditions in the actual harbourages where the Bed-bugs live. What, for instance, is the mean temperature behind the skirting board in an uninhabited house at different seasons? Is such a house a danger to the inhabitants next door? What again is the insect's power of moving along the outer face of a wall in winter, or in summer?

Work of this nature has already been carried out on other insects and has yielded results of practical value. For instance a study of the effect of the climate on tsetse flies has shown a high correlation between evaporation and the number of flies two months later. This has made it possible to forecast increases and decreases of these flies two months before they occur. Again it is known that extreme dryness kills flea larvæ, so that the number of plague fleas is much influenced by climate. On this basis plague forecasts are issued for certain critical months in Northern India and the Government of India undertakes special measures when grave risk of plague is indicated.

As has already been pointed out earlier in this report information is also required as to the effect of different toxic agents on Bed-bugs and their eggs under different conditions, and upon the subject of deterrents. Laboratory research on these various aspects of the problem should be supplemented by expert and systematic observation of the behaviour of Bed-bugs in ordinary surroundings under different climatic conditions. There are in London two institutions where research work of this nature on insects, including Bed-bugs, is being carried out—the London School of Hygiene and Tropical Medicine and the Biological Field Station of the Imperial College of Science and Technology. The former is concerned with the purely entomological side, while the latter deals with the practical application of preventive measures.

As an immediate measure we think that a circular letter should be addressed to Local Authorities calling attention to the urgency of the problem and indicating the lines upon which action may most profitably be taken.

Summary of Recommendations.

I. In our opinion it is of the first importance that sanitary officers and health visitors should be thoroughly conversant with the signs of infestation by Bed-bugs, and be able to recognise infestation in its early stages. They should have sufficient knowledge of the life history and habits of Bed-bugs to enable them to apply remedial

measures in the most economical and effective ways, and give sound instructions and advice to tenants. In many cases knowledge of this kind is conspicuously absent.

We recommend, therefore, that an instructional memorandum be prepared and issued to Local Authorities for distribution to all sanitary officers and health visitors. This memorandum should be short and concise and should indicate the main points in the recognition of Bed-bugs and the most satisfactory remedial measures. It should aim at essentials rather than multiplicity of detail. It would be, in our view, most advantageous if the memorandum were illustrated by the drawings in natural colours of Bed-bugs and their eggs in various stages which are attached to this report. The memorandum and drawings should be accompanied by a circular letter to Local Authorities drawing attention to the urgency of this problem and emphasising the need for close co-operation between the various Departments concerned.

II. In the course of our inquiries we have been struck with the lack of accurate information as to the bionomics and habits of the Bed-bug. If remedial measures are to be really successful, it is essential that our knowledge on these matters should be extended.

We recommend that arrangements be made for research work to be carried out on the following lines.

(i) The effect of climatic conditions (heat, cold, moisture, etc.) on the Bed-bug at all stages of its development and on its rate of breeding.

(ii) The effect of food supply and starvation at different seasons and at different stages of development.

(iii) The periods of survival of Bed-bugs and their eggs under different conditions.

(iv) The extent to which Bed-bugs can subsist on the blood of birds, bats, mice, etc., when deprived of human blood.

(v) The position and types of harbourages most favoured by Bed-bugs under different conditions.

(vi) The distance which Bed-bugs will travel, the factors (warmth, smell, etc.) which attract them, and whether they habitually return to the same harbourage.

More complete knowledge in these directions will make it possible to choose the most suitable conditions and seasons for fumigation and other methods of control. It will also make it possible to assess the relative importance of the various ways in which Bed-bugs may be disseminated and to organise methods of control accordingly.

(vii) The effect of various contact insecticides on Bed-bugs and their eggs under different conditions and the best methods of applying them.

(viii) The effect of toxic gases upon Bed-bugs and the concentrations and periods of exposure most effective for penetration into harbourages of various kinds.

(ix) The possible use of deterrents which, though not actively toxic to Bed-bugs, may discourage them from making use of harbourages.

(x) The elimination of harbourages.

(xi) The effect of Bed-bugs on the general health of the people and the conditions under which they may carry disease.

It is obvious that it would not be possible, without a large expenditure of time and labour, to complete such a programme of research in its entirety. We think, however, that research on these lines will produce results of great practical value to Local Authorities in their efforts to deal with Bed-bugs.

We have the honour to be, Sir,

Your obedient Servants,

G. W. Monier-Williams, Chairman.
P. H. Henderson.
C. R. Kerwood.
A. W. McKenny Hughes.
D. Morrell
Philip Stock, Secretary.

Ministry of Health.
22nd December, 1933.

APPENDIX I.

The following are the results of a qualitative examination carried out in the Chemical Laboratory of the Ministry of Health of insecticides submitted by Local Authorities.

A. Liquids.

1. A milky fluid with a fatty odour, and a faint acid reaction to litmus. On standing a layer of liquid fatty acid rose to the surface.
   Super-fatted soap solution, probably containing extract of pyrethrum or similar substance.

2. Brown fluid with odour of phenol and nitrobenzene. A heavy brown oil separated on standing.
   Paraffin + phenols + nitrobenzene.

3. Clear, amber coloured, mobile fluid with phenolic odour.
   Paraffin + phenols (and possibly essential oils).

4. Clear, light-brown fluid with a smell resembling that of acetone. It was alkaline and formed a lather on being shaken.
   Alkaline soap solution containing a little phenol a volatile oil and traces of an essential oil with odour of cedarwood.

5. Clear, light-brown fluid with a pleasant aromatic and slightly phenolic odour.
   Paraffin + phenols + essential oil with odour of lemon.

6. A greyish-brown emulsion with a smoky odour. Strongly alkaline to litmus.
   Soap solution + wood creosote.

7. Clear, viscous, amber coloured fluid with a penetrating odour and alkaline reaction.
   Soap solution + formaldehyde.
   (*See* No. 22)

8. Clear amber coloured fluid with odour of almonds.
   Paraffin + phenols + nitrobenzene. It also contained a small quantity of a basic yellow dyestuff, which on acidification gave a brilliant magenta colour.

9. Not homogeneous. Practically colourless mobile oil containing a little heavy yellow oil. Odour phenolic and almond-like.
   Paraffin + nitrobenzene + small quantity of phenols.

10. Clear, amber coloured, mobile fluid with a pleasant smell resembling lemon.
    Paraffin + phenols + essential oil (lemon).

11. Clear, amber coloured, mobile fluid with a musty odour.
    Paraffin + phenols + unidentified substance.

12. Clear green mobile fluid with faint aromatic odour.
    Paraffin + small quantity of phenols + basic yellow dyestuff. A neutral substance which imparted an intense green colour to the paraffin, was not separated or identified.

13. Pale yellowish-green mobile fluid with a faint aromatic odour.
    Paraffin + chlorinated hydrocarbons + phenols.

14. Clear amber coloured, mobile fluid with a phenolic odour.
Paraffin + phenols + nitrobenzene.

15. Pale green, mobile fluid with an odour resembling lemons.
Paraffin + essential oil (lemon).

16. Turbid, yellowish-green mobile fluid with odour of paraffin.
No substance other than paraffin was identified.

17. Opaque, dark-brown, viscous fluid with an odour like creosote.
Creosote oil distillate from coal tar.

18. Dark-brown, viscous fluid with an aromatic odour.
Paraffin + sulphonated oil (probably castor oil) + essential oil (lemon).

19. Pale green mobile fluid.
Paraffin + substance with phenolic properties.

20. Green mobile fluid with pleasant odour.
Paraffin + methyl salicylate.

21. Pale-amber, mobile fluid with an aromatic and phenolic odour.
Paraffin + phenol + salicylic acid + chlorinated hydrocarbons.

22. Clear, viscous, amber coloured fluid with a penetrating odour and strong alkaline reaction.
Soap solution + formaldehyde.
(*See* No. 7.)

23. Amber coloured fluid, with slight phenolic odour.
Paraffin + phenols with possibly a little essential oil.

24. Almost colourless mobile fluid with a strong odour of vanilla.
Paraffin + phenols + chlorinated hydrocarbons + piperonal.

25. Clear amber coloured fluid smelling strongly of almonds.
Paraffin + nitrobenzene (and possibly a little benzaldehyde).

26. Dark brown liquid with odour of creosote.
Composition similar to the Lysol type of disinfectant.
Approximate analysis showed :—

50 per cent. phenols.
20 per cent. fatty acids and resins.
20 per cent. neutral oils.

27. Milky emulsion which on standing separated into two layers. It had an odour of carbolic acid and was faintly alkaline to litmus.
Paraffin + phenols + resin soap.

28. Almost colourless mobile fluid with phenolic odour.
Paraffin + phenols.

29. Practically colourless mobile fluid with penetrating odour.
Paraffin + formaldehyde + chlorinated hydrocarbons.

B. Solids.

30. A white crystalline powder.
Borax + sugar.

31. A block of fused sulphur fitted with a wick for burning. The sulphur contained a small quantity of nitre and iron oxide.

32. White amorphous powder.
    Sodium silico-fluoride.

33. Yellow fibrous powder.
    Apparently powdered derris root or similar substance.

34. Light brown powder with an odour of spice.
    Borax + pyrethrum and possibly a little derris root.

35. Cream coloured powder with strong odour of menthol.
    Borax + menthol + powdered derris root or similar substance.

APPENDIX II.

GLASGOW SYSTEM OF SUPERVISION OF SLUM CLEARANCE RE-HOUSING SCHEMES.

Under the Glasgow Scheme for the control of bugs much importance is attached to keeping under observation tenants of the new Council houses. For this purpose a number of Nurse Inspectors, who are specially trained in the detection of vermin, are included on the staff of the Public Health Department. They co-operate closely with the City Improvement Department by notifying disrepair of plasterwork, sanitary fittings, etc. Broadly speaking, for efficient supervision a Nurse Inspector is required for every 1,000 houses. Within a few days of new tenants coming into residence a Nurse Inspector visits and carefully examines the premises and furniture for traces of bugs.

Each Nurse Inspector carries a flash-lamp and a pair of pincers—the flash-lamp for showing up any bugs which may be lurking in the cracks and corners of furniture, etc., and the pincers for removing the nails from the backs of pictures, as it has been found that the backs of pictures and even clocks are a frequent harbourage. Padded or upholstered furniture, the under parts of chairs and wooden or tin trunks are carefully examined. The drawers are taken out of wooden chests, beds are turned out, and the bed-boards and iron parts of the beds examined.

If bugs, casts or eggs are found, a careful search is made to trace the source of infestation, instructions are given in regard to cleansing and the house is revisited at short intervals until everything is satisfactory. During the first three months of their tenancy all tenants are visited at least once a month, and careful watch is kept on broken plaster, picture rails, wooden beadings, door facings and other places, etc., where bugs could harbour. If a house is found to be unsatisfactory a re-visit is always paid within a few days and, if necessary, further visits are made. It is seldom, however, that infested houses are not cleansed by the second visit, even in the case of dirty tenants. At each re-visit the backs of pictures are examined and a look out is kept for any additional furniture which may have been added since the previous visit.

A record of the inspections is kept on special cards, a specimen of which is attached. A red corner indicates that the tenants are known to have come from a bug-infested house.

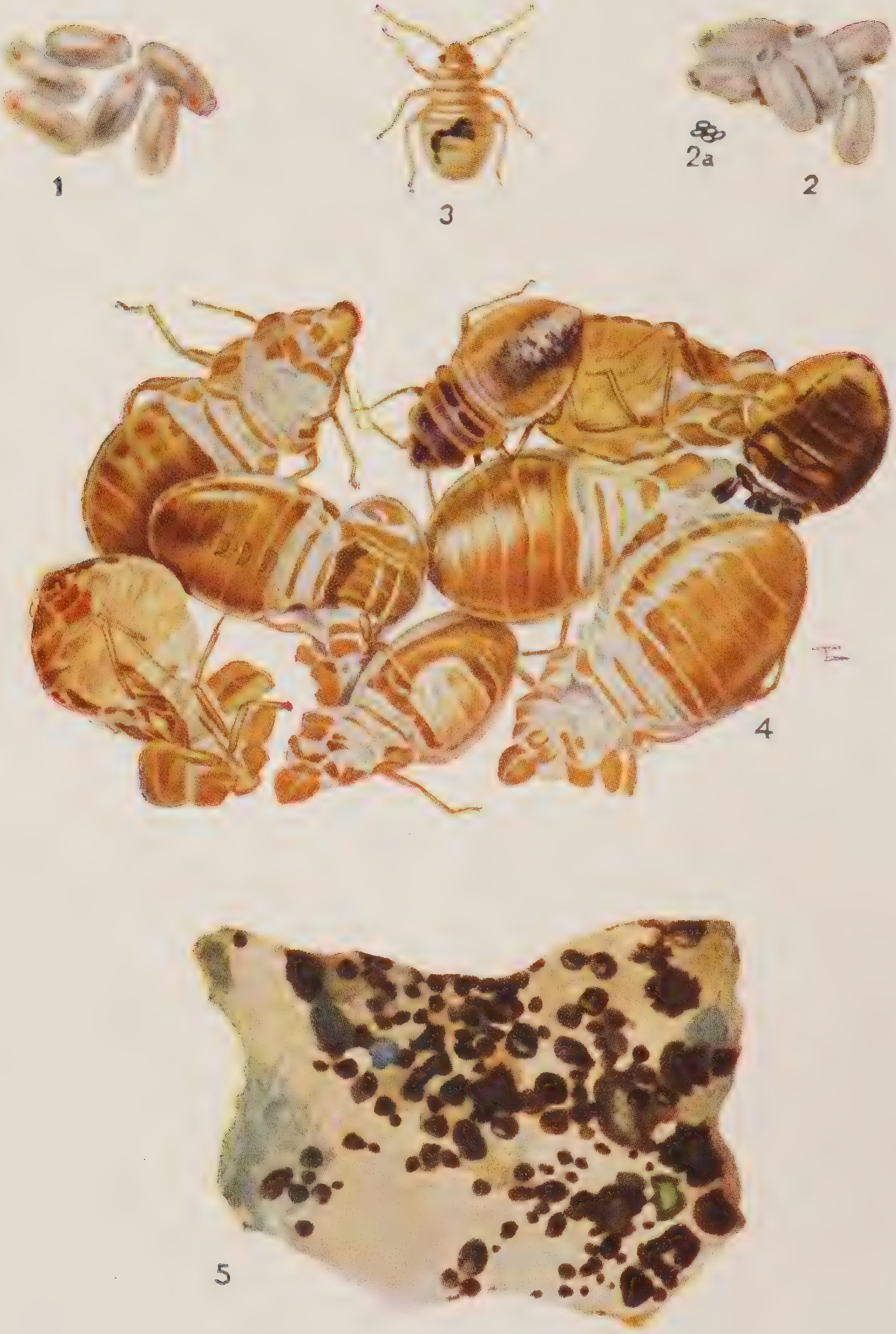
When filling in a card the following abbreviations are used to save time :—

K.=	Kitchen or living room.	Fl.=	Floor.
S.=	Scullery or kitchenette.	Ww.=	windows.
R.=	Room.	c.=	Clean.
B.R.=	Bathroom.	f.=	Fair.
St.=	Stove.	d.=	Dirty.
Bh.=	Bath.	u.=	Untidy.
Bs.=	Brasses.	du.=	Dusty.

R.—Indicates necessity to re-visit.

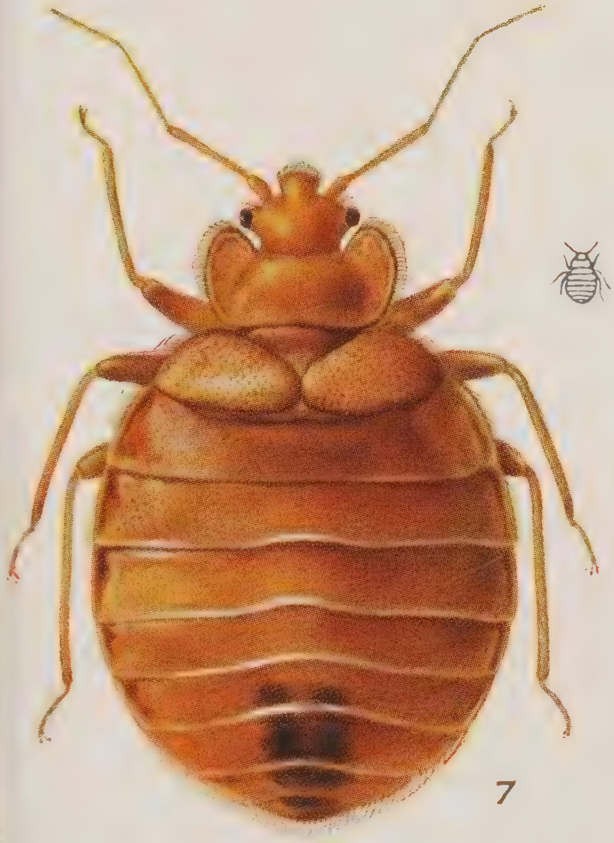
S/o (in red ink) indicates that the tenant is still in occupancy of house at end of the year.

C.C. means clean at beginning and end of year and is used for preparing the annual return.



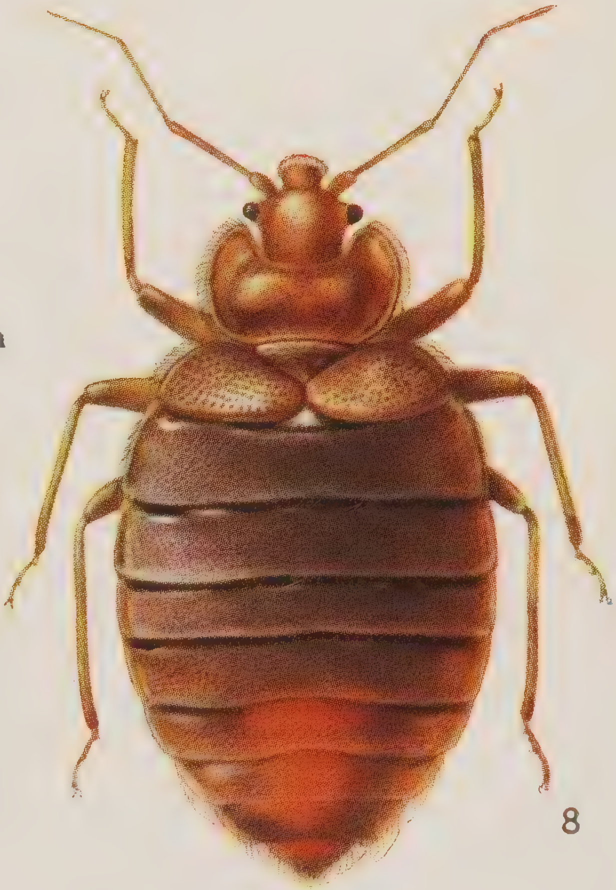
1. Fertile eggs (x 8).
2. Empty egg-shells (x 8). 2a. Natural size.
3. Young Bed-bug (first stage) (x 8).
4. Cast skins (different stages) (x 8).
5. Excrement on wallpaper (x 12).

6



7

7a



8

6. A group of Bed-bugs in various stages (x 8).

7. Adult Bed-bug—unfed (x 12). 7a. Natural size.

8. Adult Bed-bug—after feeding (x 12).

SLUM CLEARANCE REHOUSING SCHEME.

SCHEME

ADDRESS

POS.

DATE OF ENTRY

NO. OF APTS.

TENANT

FORMER ADDRESS

DATE OF INSPECTION	INMATES		OTHER OCCUPANTS		
	ADULTS	CHILD	ADULTS	CHILD	RELATIONSHIP

DATE OF INSPECTION	DETAILS RE CLEANLINESS OF HOUSE	CONDITION RE BUGS AND ACTION TAKEN	DEFECTS NOTIFIED TO IMPROVEMENTS DEPT. AND NUISANCES	CLEAN	FAIR	Unsatis-factory	DIRTY

APPENDIX III.

A Bibliography of selected papers on the Bed-bug (*Cimex lectularius*, Linn.)

The papers have been grouped for convenience of reference into (i) Biological, (ii) Medical, (iii) Methods of control, (iv) Miscellaneous. This grouping is somewhat arbitrary, since many of the papers deal with the subject from several angles. The abbreviations used are those of the World list of Scientific Periodicals, 1927, vol. II.

BIOLOGICAL.

ARAKAWA, Y. (1932): *Dobuts.Zasshi.*, **4**, 198. (In Japanese.)
Stink glands; poison in salivary glands.

——— (1932): *Insect Wld.*, **36**, 335. (In Japanese.)
The bite of Bed-bugs.

BACOT, A. W. (1914): *Bull. Ent. Res.*, **5**, 111.
Eggs of *Cimex lectularius* can live at 40° to 50° F. for 31 days and at 28° to 32° F. for 48 hours. Five to 8 days at the latter temperature reduced the percentage hatching to 25 per cent., and longer exposures (10 to 15 days) were fatal. Exposure to 113° F. prevents hatching. The eggs hatch after burial in dry or wet sand for about a week at 45° to 50° F. if they are then uncovered and kept at a favourable temperature. Immersion in water at 60° to 63° F. for 5 days has no effect on hatching if the eggs are then kept under favourable conditions. They also live for at least 3 days in water at 45° to 50° F. and for 48 hours when the water is frozen.

Immersion in lime water for 46 hours is fatal. The eggs survive partial embedding in a wet plaster surface if emergence is not prevented.

Newly hatched Bed-bugs when unfed can live at 28° to 32° F. for periods up to 18 days. They can also withstand chilling, thawing, re-chilling and again thawing over shorter periods. Exposure to cold moist air after a full meal is often fatal, probably because of humidity rather than cold. At moderate temperature (60° to 65° F.) they may live for 136 days unfed and after a meal 9 months. When unfed at 75° F. with humidity between 0.65 and 0.70 the average life is 10 days, with occasional survival up to 21 days. At 88° F. with humidity between 0.70 and 0.80 the average life is 7 days, the longest survival being 11 days. At 96° F. with humidity at 0.25 the average life is 5 days; individuals have survived for 8 days. Exposure to 113° F. is fatal within a few minutes.

BUCHNER, P. (1921): *Biol. Zbl.*, **41**, 570.
A new symbiotic organ of the Bed-bug.

CHATTON, E. and BLANC, G. (1918): *Bull. Soc. Path. exotique*, **11**, 382.
Fed Bed-bugs on the gecko, *Tarentola mauretanica.*

CHAVIGNY, T. (1924): *Les Animaux parasites de l'homme et de l'habitation*, Doin, Paris.
Popular account of the Bed-bug and other insects.

CHRISTOPHERS, S. R. and CRAGG, F. W. (1922): *Ind. J. Med. Res.*, **9**, 445.
A detailed description of the genitalia of both sexes.

CORNWALL, J. W. and PATTON, W. S. (1914): *Ibid.*, **2**, 569.
No evidence of an anticoagulin or of a coagulin in the saliva of *C. rotundatus.*

CRAGG, F. W. (1915): *Ibid.*, **2**, 698.
A full description of the organ of Berlese, copulation, and of the alimentary tract.

Cragg, F. W. (1920): *Ibid.*, **8**, 32.
A detailed description of the reproductive system of *Cimex*.

——— (1923): *Ibid.*, **11**, 449.
Both sexes of *Cimex* are fully mature soon after the final moult and the female may be impregnated before either sex has fed. The female will feed as readily before impregnation as after. The eggs do not begin to develop until they are fertilised and only a few eggs are laid until the female has had a feed of blood. The number of eggs depends upon the amount of food the female obtains and also upon the state of the male. The females impregnated by unfed males do not produce so many eggs as females impregnated by fully nourished males. Copulation is very frequent during normal life. A male can fertilise at least three females in 24 hours and it is probable that copulation occurs not less than once a day in nature.

One impregnation does not enable the female to lay indefinitely. In two experiments in which the impregnating males had not been fed 48 and 43 normal eggs were laid; in two experiments in which the males were fed the females laid 173 and 133 normal eggs. Towards the end of these experiments when the supply of spermatozoa was becoming exhausted, only malformed and sterile eggs were laid. The presence of more than one male makes no difference in the number of eggs laid. The spermatozoa are not retained intact by the female during periods of starvation at temperatures suitable for oviposition; if the period is long enough no eggs are laid when feeding is resumed. If conditions are otherwise favourable to oviposition shortage of spermatozoa results in the production of deformed and sterile eggs while lack of food does not.

——— (1925): *Ibid.*, **12**, 451.
The reproductive system of *Cimex*: impregnation.

Cummings, B. F. (1917): *Brit. Mus.* (*Nat. His.*) *Econ. Ser.* **5** [Revised 1918 and 1932.]
Life history, etc., of the Bed-bug.
This pamphlet is so well known that further comment is unnecessary.

Doten, S. B. (1916): *Rep. Nevada Agric. Expt. Sta.*, p. 38.
Thirty-one Bed-bugs obtained from a lodging-house were placed in tubes in a box and kept under shelter in the open air from January 21st till April 10th. Only 11 survived, and these remained alive in a refrigerator at a temperature of between 40° and 50° F. till July 1st. Some very tiny bugs were kept in cold storage nearly 3 months without food. Eggs kept under the same conditions hatched promptly when the temperature was raised.

Duncan, J. T. (1926): *Parasitology*, **18**, 238.
The bactericidal principle present in the alimentary tract of insects.

Frickhinger, H. W. (1919): *Z. angew. Ent.*, **6**, 170.
Draws attention to H. Hülsen's observation that the book scorpion, *Chelifer cancroides*, feeds on Bed-bugs.

Girault, A. A. (1910): *J. Econ. Biol.*, **5**, 88.

——— (1912): *Ibid.*, **7**, 163.

——— (1914): *Ibid.*, **9**, 25.
Gives the biology of the Bed-bug. His observations were made at odd times and are not always quite accurate in the light of present knowledge. He kept Bed-bugs in captivity for periods up to a year and watched their breeding habits. The greatest number of eggs laid by any one female was 190 and the least in the same series 86. He found that they would feed on the blood of mice, sparrows and guinea-pigs

and would lay eggs afterwards. Apparently he did not distinguish the male from the female.

HASE, A. (1918): *Die Bettwanze (Cimex lectularius L.) ihr Leben und ihre Bekämpfung.* Paul Parey, Berlin.

——— (1918): *SitzBer. Ges. naturf. Fr. Berl.*, p. 311.

Copulation of Bed-bug. Does not copulate after one month's starvation. Food and warmth stimulate copulation. One copulation will produce over 100 eggs at the rate of 4 or 5 a day.

——— (1919): *Zbl. Bakt.*, [*I. Abt. Orig.*]. **83**, 22.

Bed-bugs cease to lay eggs after the following periods have elapsed since the last meal :—

7 days at 35° to 37° C., 12 days at 22° to 26° C., 27 days at 15° to 18° C.

The number of eggs laid during a fasting period varies greatly. The largest number observed was 23 eggs during a fast of 12 days. In two cases eggs continued to be laid for 21 days after a meal. Young healthy females, after one fertilisation, will lay an average of 3 to 4 eggs daily for periods up to one or more months. On some days they may lay as many as 10 or 12 eggs.

At the optimum temperature of 30° C. and with abundant feeding, the Bed-bug goes through its stages from nymph to adult in about 28 days. At room temperature this series of changes is lengthened to 6 to 8 weeks.

——— (1930): *Zeitschrift für Parasitenkunde*, **2**, 368.

Describes an apparatus for breeding Bed-bugs in quantity. Bed-bugs often draw from their victims colourless lymph instead of blood. This is not due to any deformity or filtering action of the sucking apparatus. After lymph meals the excreta are colourless or grey. Sometimes a meal consists of a mixture of blood and colourless lymph. Information is given as to the appearance of the excreta under different conditions, and the effect of temperature, food and age upon excreta. The excreta of the nymph before its first moult are always light in colour even after feeding on blood.

Digestion lasts 15 days at room temperature, 10 days at 30° C.

Exposure to 2° C. for 10 days destroys 1 to 20 per cent. of the eggs, 22 days 50 to 75 per cent. of the eggs, 30 days 90 per cent. of the eggs. Short exposure to −15° C. kills 75 per cent. of *C. lectularius* eggs and 100 per cent. of *C. rotundatus* eggs.

——— (1933): *Ibid.*, **5**, 708.

Animal hypnosis or tonic immobility in blood-sucking insects while feeding.

JANISCH, E. (1933): *Ibid.*, **5**, 460.

A study of the artificial breeding of Bed-bugs and of the variations observed in the individuals of a Bed-bug population and in their resistance to adverse conditions. The author stresses the importance of a careful selection of material for biological investigations and indicates the unreliability of average values.

JONES, R. M. (1930): *Ann. Ent. Soc. Amer.*, **23**, 105.

A Bed-bug can lay eggs before it has been fed, and never moults more than five times. Unfed 1st instar nymphs can live a maximum period of 100 days at 13° C. with relative humidity 34 per cent.

Fifty adult Bed-bugs were reared from the egg at 27° C. with 75 per cent. relative humidity. The average times required for the different stages were—incubation period 5.9 days, first instar 5 days, second instar 4.5 days, third instar 4.2 days, fourth instar 4.6 days and the fifth instar 6 days. The average time required to reach the adult

stage was 30.2 days. The pre-oviposition period of the adult, the incubation period of the eggs, and the development period of the nymphs showed much variation under room conditions, but remained relatively constant at uniform temperature and humidity. The adult female will lay eggs before feeding. Temperature and relative humidity are important factors in the incubation period of the egg and the life of the nymph without food. The length of life varies inversely with increase of temperature above 13° C. Relative humidities below 50 per cent. cause death of the nymphs in less time than those between 50 per cent. and 75 per cent.

The amount of blood consumed at a " meal " and during the entire growing period was ascertained.

The size and weight of the eggs, weight at the different stages, and the measurements of the five instars and the adult stage are given.

The Bed-bug does not hibernate during the winter when the temperature, relative humidity and food conditions are suitable for continued activity.

JORDON, K. (1922): *Ectoparasites*, **1**, 284.
The organ of Berlese.

KEMPER, H. (1929): *Zeitschrift für Morphologie und Ökologie der Tiere*, **15**, 524.
The stink gland of Bed-bugs.

——— (1930): *Ibid.*, **19**, 160.
Viability of Bed-bugs in various stages when fasting. Newly hatched nymphs are least resistant to hunger. Without food they average five weeks of life, with 10 weeks as a maximum. Adults can live up to 38 weeks (average 20 weeks) without food.

——— (1932): *Ibid.*, **24**, 491.
The mechanism of the blood-sucking action in Bed-bugs.

——— (1929): *Z. Desinfekt.*, **21**, 61.
Observations on the perforation of the skin and sucking of blood by Bed-bugs.

——— (1929): *Ibid.*, **21**, 285.
The senses of perception in Bed-bugs. Attraction of human body is not perceptible at distances greater than 4 cm. Bed-bugs find their food by wandering at random.

——— (1930): *Z. Desinfekt. Gesundheitsw.*, **22**, 406.
The effect of temperature and nourishment on reproduction, longevity and resistance of Bed-bugs.

——— (1932): *Zeitschrift für Parasitenkunde*, **5**, 112.
Rupture of the intestinal tract can often be observed to occur in Bed-bugs and is usually fatal.

KLINGMÜLLER, —. (1917): *Münch. med. Wschr.*, **64**, 1,653.
A general account of the Bed-bug, its life history, habits, etc.

KONOKHOV, —. (1924): *Russ. J. Trop. Med.*, p. 49.
Anopheles sp. attacked Bed-bugs, withdrawing all their blood.

LAVIER, G. (1921): *Lab. Paras. Fac. Med., Paris.*
Gives a list of various bacteria, etc., associated with *C. lectularius*.

LEEFMAN, S. (1919): *Teysmannia*, **30**, 12. (In Dutch).
Observations on the biology of the Bed-bug.

LEON, N. (1924): *Ann. Parasit. hum. comp.*, **2**, 71.
Mouth-parts of Bed-bugs.

MELLANBY, K. (1932): *Parasitology*, **24**, 419.

A method is described by which individual Bed-bugs weighing only 5 mg. can be accurately weighed and their loss of weight measured during starvation.

Fasting Bed-bugs were kept for various periods at five temperatures ranging from 8° to 37° C. and at relative humidities of 0, 30, 60 and 90 per cent. at each temperature. The same amounts of food reserves were used up at each humidity for one temperature and more water was evaporated from those kept in dry air than from those in moist. Protein was the main food reserve used.

Although the rate of loss of water was greatest in dry air it was relatively greater in moist air when the saturation deficiencies are compared. Insects conserve their water in dry air, but their surface area being so great in comparison with their volume they cannot prevent all evaporation. The evaporation is at a rate nearly proportional to the saturation deficiency of the air.

In moist air water is evaporated freely. It is suggested that the spiracles are kept closed more in dry air and less in moist, which accounts for the fact that the rate of evaporation is proportionately greatest in moist air.

MURRAY, C. H. (1914): *Ibid.*, **7**, 278.

A lengthy account of the anatomy of *Acanthia lectularia* L. (*Cimex lectularius* L.)

PINTO, C. (1927): *Bol. biol. S. Paulo*, **8**, 115.

Describes a spiracle on the tarsus of *Cimex hemipterus* and *C. lectularius*.

PURI, I. M. (1924): *Parasitology*, **16**, 269.

Stink organs.

RIVNAY, E. (1930): *J. Parasit.*, **16**, 246.

Experiments in artificial feeding of Bed-bugs. Heat is the only agent which attracts the Bed-bug and stimulates its feeding desire. The Bed-bug will not attack any object which emits a repellent odour even though it radiates heat. The Bed-bug will make no attempt to pierce any moist object, nor feed on any exposed liquid. *C. lectularius* will not attempt to pierce too smooth a surface.

By taking advantage of the positive thermotropic reaction of the Bed-bug, and by the use of a very thin chicken-skin membrane, Bed-bugs could be induced to feed upon warm chicken broth, warm sugar solution stained with Guinea Green and blood serum from fresh chicken blood. The surface of the chicken skin employed must be of the proper texture, and free from surface moisture and repellant odours.

——— (1930): *Ann. Ent. Soc. Amer.*, **23**, 758.

Further experiments indicating that heat is the only factor which attracts Bed-bugs. They will feed on any warm-blooded animal, showing no preference in selecting the host. This is attributed to the difference between the animal's temperature and that of its surroundings. This difference must be at least 2° C. before any reaction takes place. Supports de Geers' statement that cannibalism is occasionally practised on newly fed Bed-bugs, especially those crippled or those with burst gut which are raised by the blood ingested to the necessary degree of temperature in relation to the immediate environment.

——— (1932): *Parasitology*, **24**, 121.

Odour as well as heat attracts Bed-bugs; the strongest attraction is a combination of the two. Neither were attractive to Bed-bugs at a greater distance than about 4 to 5 cm. Bed-bugs prefer contact

with a rough surface even if it is in the light. A smooth surface repels them. The Bed-bug can differentiate taste only after it has imbibed a certain quantity of liquid. Water repels Bed-bugs. Heat is an important factor in stimulating Bed-bugs to obtain food. The reactions to heat are affected by the state of nutrition and moulting but not by light and humidity. The Bed-bug detects heat very slowly. At 23° C. and at a distance of 4 cm. about $1\frac{1}{2}$ min. elapsed before the Bed-bug reacted to the heat of the hand. At a lower temperature the time was longer. At room temperature a difference of about 2° C. was necessary to cause reaction to heat. Bed-bugs, although attracted to heat, are repelled when the temperature is too high. Bed-bugs were repelled by objects at 43° C. at a distance of about 3 cm. Bed-bugs have a sense of smell, but react only when very close to the source of the smell. The odours of blood, muscle, subcutaneous tissue and clean washed skin seemed to have no influence upon the Bed-bug ; that of bile repelled them ; liver at first attracted and then repelled them. The odour of perspiration sometimes repels and at others attracts Bed-bugs according to its state of decomposition. Of the substances tested the odours of sebum and cerumen had the greatest attracting power. The Bed-bug apparently discriminates between foods by taste. Negative reactions to water counterbalance positive reactions to heat and odour. The instinct to be in contact with a rough object, rather than the negative reaction to light, underlies the gregarious habit of Bed-bugs as well as their search for places of retreat.

RIVNAY, E. (1932) : *Bull. Soc. ent. Égypte,* **16,** 13. (From *Rev. Appl. Ent.*).

Relative humidity has no effect on the rate of development of *C. lectularius* L. Preliminary experiments with starving Bed-bugs show that the higher the temperature and the lower the humidity the more rapidly they die.

ROUBAUD, E. (1928) : *Bull. Soc. Path. exotique,* **21,** 224.

Found Bed-bugs feeding on white mice in a dark and heated cellar in Paris. They were not well nourished.

TITSCHACK, E. (1928) : *Zool. Jahrb.,* **45,** 437.

The sensory nerve of the Bed-bug.

——— (1930) : *Zeitschrift für Morphologie und Ökologie der Tiere,* **17,** 471.

Gives many observations on the growth and life history of the Bed-bug.

WIGGLESWORTH, V. B. (1931) : *Proc. Ent. Soc. Lond.,* **6,** 25.

——— (1931) : *Nature. Lond.,* **127,** 307.

During starvation the Bed-bug, like many other insects, swallows much air, which serves to maintain body volume in place of the food and tissues that are consumed. If the first stage larvae of the Bed-bug were kept for several weeks in a moderately dry atmosphere (for example, 50 per cent. relative humidity at 23° C.), as the circulating fluids became less, the gut, containing bubbles of air, became herniated into the bases of the limbs, and might extend far down the femora. If such insects were then exposed to a saturated atmosphere, most of them died in a few days ; others recovered, moisture was taken in and the bubbles of air disappeared from the limbs. On the other hand, if they were kept in the dry atmosphere, the gut wall eventually broke, and the bubbles of air were set free into the body cavity. The larva in this state was often still capable of sucking blood, and if given a moderate meal both the bubbles in the gut and the free bubbles in the limbs disappeared into solution. During this process a certain

amount of blood usually escaped into the body cavity, and the red corpuscles could be seen circulating in the blood of the insect. In some larvae such corpuscles continued to circulate, apparently unchanged, for 3 weeks, long after the blood in the gut had been completely digested.

Three points of interest are presented by this paper :—(1) Desiccation in an insect can lead to femoral hernia and surgical emphysema ; (2) In the desiccated condition the larvae are apparently hygroscopic and can absorb water vapour from a moist atmosphere (though the possibility of their taking up minute droplets of fluid condensed on the proboscis has not been entirely excluded) ; (3) Small foreign bodies, such as blood corpuscles of vertebrates, can circulate in the blood stream, apparently indefinitely, without being removed by phagocytosis or otherwise.

MEDICAL.

Adie, H. A. (1922) : *Ind. J. Med. Res.*, **9**, 5 and 255.
Cimex and Leishman—Donovan bodies.

——— *Ibid.*, **10**, 236.
Cimex and kala-azar.

Archibald, R. G. (1914) : *R.A.M.C. Jl.*, **23**, 479.
Bed-bugs are not concerned in the transmission of kala-azar.

——— (1917) : *J. Trop. Med.*, **20**, 183.
C. lectularius transmits 7-day fever in Sudan (no tests made).

——— (1923) : *Amer. J. Trop. Med.*, **3**, 307.
Kala-azar in the Sudan.

Arkwright, J. A. (1923) : *Trans. Soc. Trop. Med. Hyg. Lond.*, **17**, 3.
Rickettsia and *Cimex*.

Arkwright, J. A., Atkin, E. E. and Bacot, A. (1921) : *Parasitology*, **13**, 27.
Hereditary Rickettsia-like parasite of the Bed-bug.

Arnold, W. J. J. (1914) : *Brit. Med. J.*, **1**, 299.
Beri-beri and Bed-bugs.

Awati, P. R. (1922) : *Ind. J. Med. Res.*, **10**, 579.
Kala-azar in Assam.

Bacot, A. W. (1915) : *J. Hyg. Camb.* (*Plague Suppl.*), **4**, 777.
For a percentage of Bed-bugs and probably for all newly hatched ones a meal of septicaemic blood from a mouse dying of plague is fatal.
Bed-bugs which are not killed by the infecting meal can carry *B. pestis* and re-infect mice after a period of 48 days' starvation.
The development of *B. pestis* within the crop of the Bed-bug differs generally from that in the stomach of the flea in its slower and looser growth, this being accompanied by, and possibly due to, the preservation of the structural character of the blood for many days after its ingestion into the crop.
The absence of any definite valve between the pump and the crop together with the looser nature of the growth within the Bed-bug prevents such mechanical blockage as causes regurgitation and mouth infection in fleas. Mouth infection when not caused by accidental or other injury to the Bed-bug while feeding may be due to interruption followed by a second attempt.

Belai, A. (1922) : *Wien. klin. Wschr.*, **35**, 57.
Experiences in prisoners' camps in Russia during the war suggested that Bed-bugs were capable of transmitting malaria.

Bisset, E. (1914) : *Ind. J. Med. Res. Suppl.*, **4**, 114.
Relapsing fever.

Blacklock, B. (1914): *Brit. Med. J.*, **1**, 912.
Finds that *Trypanosoma cruzi* is capable of living and multiplying in *C. lectularius*, but is not readily transmissible by feeding. In only one case was it so transmitted. It could, however, be transmitted by injection of extracts of faeces, etc.

Blacklock, B. and Lowrie, E. M. (1931): *Ann. Trop. Med. Parasit.*, **25**, 359.
Viable forms of *Leishmania tropica, donovani, donovani var. infantum* and *Brasiliensis* can be passed up to 35 days in the faeces of artificially infected *C. lectularius*. *Herpetomonas culicidarum* was recovered from faeces of artificially infected Bed-bugs.

Blanchard, M., Lefrou, G. and Laigret, J. (1922): *Bull. Soc. Path. exotique*, **15**, 385.
Bed-bugs and infectious jaundice; preliminary note.

——— (1923): *Ibid.*, **16**, 184.
Transmitted spirochaetosis, which closely resembles, and may even be indentical with, infectious jaundice, to guinea pigs by means of Bed-bugs.

Blanchard, M. and Laigret, J. (1924): *Ibid.*, **17**, 409.
Onchocerca volvulus and Bed-bugs.

Bonne, C. (1924): *C.R. Soc. Biol. Paris*, **91**, 242.
Spirochaeta icterohaemorrhagiae and *Cimex*.

Brain, C. K. (1919): *Un. S. Afr. Dept. Agric. Loc. Ser.* No. 57.
Bed-bugs not transmitters of typhus.

British Med. J., (1918), **I**, 675.
Ichterohaemorrhagic jaundice and Bed-bugs.

Brumpt, E. (1913): *Bull. Soc. Path. exotique*, **6**, 167.
Trypanosoma lewisi can develop in the gut of *C. lectularius* and a rat was infected with the extract from the gut of an infected Bed-bug.

——— *Ibid.*, **6**, 172.

——— (1914): *Ibid.*, **7**, 132.

——— *Ibid.*, **7**, 702.
Trypanosoma cruzi and *Cimex*.

Brumpt, E., Gonzalez, — and Lugo, —. (1913): *Ibid.*, **6**, 382.
Trypanosoma cruzi and *Cimex*.

Brumpt, E. and Pedroso, A. (1913): *Ibid.*, **6**, 752.
Since Bed-bugs are more common in towns than in the country, it is probable that Leishmaniasis in São Paulo is not transmitted by them.

Castaneda, M. R. and Zinsser, H. (1930): *J. Exp. Med.*, **52**, 649.
Typhus and Bed-bugs.

Chatton, E. and Blanc, G. (1917): *Arch. Inst. Pasteur Tunis*, **10**, 1.
Toxoplasma of the Gundi and *Cimex*.

——— (1918): *Bull. Soc. Path. exotique*, **11**, 387.
The Trypanosoma of the Gecko and Bed-bugs.

Chesney, L. M. (1916): *Practitioner*, **96**, 542.
Typhus in Serbia.

Christophers, S. R. (1922): *Ind. J. Med. Res.*, **9**, 5.
Leishmann-Donovan bodies.

Cleland, J. B. (1917): *N.S.W. Eighth rep. of Microbiological Lab.*, p. 173.
Poliomyelitis is not transmitted by Bed-bugs.

Collier, W. A. (1924): *Verh. deuts. Ges. angew. Ent.*, **4**, 69.
Bed-bugs do not carry relapsing fever. They do not carry typhus, anthrax, fowl cholera, rodent typhus, trypanosomiasis or poliomyelitis. They may act as mechanical carriers of plague and leprosy. It is not known whether they can carry oriental sore and kala-azar.

Cornwall, J. W. (1916): *Ind. J. Med. Res.*, **4**, 105.
Kala-azar.

——— (1923): *Ibid.*, **11**, 587.
Resistant forms of *Leishmania donovani.*

Cornwall, J. W. and La Frenais, H. M. (1916): *Ibid.*, **3**, 698.
L. donovani flagellates can live in the stomach of the Bed-bug for 29 days, but the Bed-bug is unable to transmit the flagellates to sterile blood cultures through a rabbit skin membrane in the act of feeding.

——— (1922): *Ibid.*, **9**, 533.
Kala-azar.

Cornwall, J. W. and Menon, T. K. (1917): *Ibid.*, **4**, 672.
Kala-azar: on rare occasions living flagellates of *L. donovani* may be found in the intestines and rectum of artificially infected Bed-bugs. Many living Lygeid herpetomonads will pass into the intestine and rectum of artificially infected Bed-bugs. *C. rotundatus* often succumbs after a feed infected with bacteria. If it survives the infecting organism is sometimes recoverable by culture from the stomach. In no case were infected Bed-bugs able to infect sterile culture media in the act of feeding. The transmission of bacterial infections in nature in the act of biting must be of rare occurrence. Attempts to obtain regurgitation of *L. donovani* flagellates by infected Bed-bugs had negative results.

——— (1917): *Ibid.*, **5**, 37.
Plague and Bed-bugs.

——— (1918): *Ibid.*, **5**, 541.
Kala-azar.

Cowdry, E. V. (1923): *J. Exp. Med.*, **37**, 431.
Rickettsia and Bed-bugs.

Cox, F. S. (1917): *Commonwealth of Australia Quarantine Service Report*, No. 13.
There is no evidence that Bed-bugs transmit typhus fever.

Davis, N. C. (1928): *Amer. J. Hyg.*, **8**, 457.
C. lectularius and Filaria in N. Argentina.

de Mello, F. and Cabral, J. (1926): *Bull. Soc. Path. exotique*, **19**, 774.
Leprosy.

Donaldson, A. W. H. (1925): *Ann. Med. Sanit. Rep. Somaliland*, 29.
Relapsing fever.

Dunderdale, G. (1921): *Trans. Soc. Trop. Med. Hyg. Lond.*, **15**, 190.
Filarial infection in British East Africa.

Escomel, E. (1924): *Bull. Soc. Path. exotique*, **17**, 906.
Review of insects likely to carry disease in Peru.

Fantham, H. B. and Porter, A. (1914): *Some minute animal parasites or unseen foes in the animal world.* Methuen, London.
Protozoology.

Fox, C. (1913): *Philipp. J. Sci.*, **8B**, 119.
Plague in Iloilo probably transmitted by Bed-bugs.

Franchini, G. (1912): *Bull. Soc. Path. exotique*, **3**, 817.
Parasites of Leishmaniasis do not live in the digestive tube of *Cimex lectularius*.

Francis, E. (1927): *Publ. Hlth. Rep. Wash.*, **42**, 2,763.
Tularemia in *Cimex lectularius*.

Francis, E. and Lake, G. C. (1922): *Ibid.*, **37**, 83.
Tularemia can be transmitted to mice by Bed-bugs chiefly when the mice eat them.

Friedman, G. A. (1919): *Med. Rec. N.Y.*, **95**, 14 (from *Rev. Appl. Ent.*).
The Bed-bug may be a possible carrier of influenza.

Fry, A. S. (1920): *Ind. Med. Gaz.*, **55**, 2.
Relapsing fever is transmitted by Bed-bugs.

Gomes, E. (1923): *Brazil-med.*, **37**, 379.
Bed-bugs do not transmit leprosy.

Gouzien, P. (1923): *Bull. Off. int. Hyg. publ.*, **15**, 797.
As Bed-bugs are not present in French West Africa relapsing fever cannot be transmitted by them, but is due to *Pediculus*.

Hall, H. C. (1916): *Milit. Surg.*, **39**, 474 (from *Rev. Appl. Ent.*). Typhus fever.
The body louse, *P. humanus*, when placed in a bottle with head lice, *P. capitis*, Bed-bugs and raw meat, will first kill and devour the head lice, then the Bed-bugs, then the raw meat, then become cannibals.

Hartmann-Keppel, G. L. (1923): *Rev. Med. Hyg. trop.*, **15**, 135.
Bed-bugs play an important if not exclusive rôle in the transmission of "Leishmaniose cutanée" in North Syria.

——— (1923): *Rev. prat. Maladies des Pays Chauds*, **3**, 65.
Leishmaniose cutanée.

Heiser, V. G. (1913): *Philipp. J. Sci.*, **8B**, 109.
Improbable that Bed-bugs carry plague.

——— (1914): *Ibid.*, **9B**, 5.
Plague.

Hertig, M. and Wolbach, S. B. (1924): *J. Med. Res.*, **44**, 329.
Rickettsia.

Hoeppli, R. and Feng, L. C. (1931): *Nat. Med. J. China*, **17**, 541.
Reactions of the skin due to Bed-bugs.

Howard, C. W. and Clark, P. F. (1912): *J. Exp. Med.*, **16**, 850.
The Bed-bug and poliomyelitis.

Howell, B. W. (1916): *St. Bart. Hosp. J.*, **23**, 52.
Typhus.

Jennings, A. H. (1914): *J. Parasit.*, **1**, 10.
Bed-bugs do not transmit pellagra.

Kling, C. and Levaditi, C. (1913): *Ann. Inst. Pasteur*, **27**, 718.
Bed-bugs do not transmit poliomyelitis.

Koch, J. (1917): *Deuts. med. Wschr.*, **43**, 1,066.
Lice are by far the most important carriers of relapsing fever but possibly it may be transmitted also by Bed-bugs.

Lamborn, W. A. (1926–27): *Ann. Med. Rep. Nyasald. Zomba*, p. 24.

——— (1929–30): *Ibid.*, p. 38.
Trypanosomiasis and Bed-bugs; negative results.

Leake, J. P. (1917): *Publ. Hlth. Rep. Wash.*, **32**, 1,995.
Bed-bugs were not responsible for the outbreak of poliomyelitis in Elkins.

LEBOEUF, A. (1913): *Bull. Soc. Path. exotique*, **6**, 551.
Leprosy.

——— (1914): *Ann. Hyg. Méd. col.*, **17**, 177.
Bed-bugs do not carry leprosy.

McCULLOCH, W. E. (1925): *J. Trop. Med.*, **28**, 332.
Relapsing fever in N. Nigeria; *Cimex lectularius* is a secondary transmitter.

MACFIE, J. W. S. and GALLAGHER, G. H. (1914): *Ann. Trop. Med. Parasit.*, **8**, 379.
Were unable to transmit the trypanosome of sleeping sickness to a guinea pig by means of Bed-bugs.

MACKIE, F. P. (1914): *Ind. J. Med. Res.*, **1**, 626.
Kala-azar.

——— (1915): *Ibid.*, **2**, 942.
Of 131 Bed-bugs which were fed on cases of kala-azar only two shewed recognisable Leishmaniasis 24 hours later. In other experiments involving over 3,000 Bed-bugs no cases were observed.

MALLANNAH, S. (1923): *Ind. Med. Gaz.*, **58**, 168.
Relapsing fever; negative results.

MARTOGLIO, F. (1931): *Giorn. Med. milit.*, **79**, 53.
Relapsing fever in Africa.

MICHAEL, D. F. (1925): *Ind. J. Med. Res.*, **13**, 131.
Blood-sucking insects are not necessarily the vectors of kala-azar.

MONTEIRO, J. L. (1929): *Brazil-med.*, **43**, 1,037.

——— (1930): *Mem. Inst. Butantan*, **5**, 49.
Experimental transmission of Yellow Fever virus by the injection of an emulsion of faeces of *Cimex*.

MOON, R. O. (1916): *Lancet, Lond.*, **1**, 1,069, 1,111, 1,157.
Typhus.

MOOSER, H., CASTANEDA, M. R. and ZINSSER, H. (1931): *J. Exp. Med.*, **54**, 567.
Mexican typhus.

MOUZELS, P. (1913): *Ann. Hyg. Méd. col.*, **16**, 249.
Bed-bugs, *inter alia*, can take up the organisms of relapsing fever.

New York Medical J. (1913): p. 191.
Five cases of typhoid on island hitherto immune not traceable to any of usual sources. Finally traced to prisoner in guard house who had come from town in which typhoid was endemic. All Bed-bugs were killed by fumigation and the disease permanently disappeared.

NICOLLE, C. and ANDERSON, C. (1925): *Arch. Inst. Pasteur Tunis*, **14**, 264.
Kala-azar.

NOVIKOVA, E. I. and LALAZAROV, G. A. (1931): *Rev. Microbiol.*, **10**, 315.
Cimex and plague.

PATTON, W. S. (1912): *Proc. IIIrd Meeting Gen. Malaria Comm. Madras*, p. 221.
Gives details of the flagellate form of kala-azar in *Cimex* at different temperatures.

PATTON, W. S., LA FRENAIS, H. M. and SUNDARA RAO. (1921): *Ind. J. Med. Res.*, **9**, 240.
Herpetomonas tropica cultures are found in the alimentary tract of *Cimex hemiptera* up to 23 days.

——— *Ibid.*, **9**, 252.
Herpetomonas donovani.

PHILIP, C. B. (1930): *Ann. Trop. Med. Parasit.*, **24**, 493.
Cimex and Yellow Fever.

PINO POU, R. (1918): *Gac. méd. Caracas*, **25**, 93.

——— (1921): *Ibid.*, **28**, 111, 125, 139.
Relapsing fever.

PITTALUGA, G. (1926): *J. Trop. Med.*, **29**, 387.
C. lectularias is not a transmitter of *Leishmaniosis visceralis* in Spain.

PRICE, J. D. and ROGERS, L. (1914): *Brit. Med. J.*, **1**, 285.
Evidence tends to support the theory that Bed-bugs transmit kala-azar.

REGENDANZ, P. and REICHENOW, E. (1932): *Arch Schiffs-u. Tropen-hyg.*, **36**, 305.
Bed-bugs cannot transmit *Bartonella canis.*

ROBERTSON, A. and TRIFFIT, M. J. (1923): *Vet. J.*, **79**, 49.
Trypanosoma cruzi.

ROGERS, L. (1914): *Ind. J. Med. Res.*, **5**, 15.
Kala-azar.

ROSENAU, M. J. and BRUES, E. C. (1912): *Harv. Alumni Bull.*, **15**, 140.
Poliomyelitis.

ROSENHOLZ, H. P. (1927): *Zbl. Bakt.* (*Abt. Orig.*) **102**, 179.
Bed-bugs infected with European and African relapsing fever may carry the infection for a long time, possibly for the whole of their life. It is not easy to gauge the extent to which they assist in spreading this fever, but they may occupy an important place among the other known carriers of the disease.

ROSENHOLZ, H. P. and GILBERT, M. J. (1927): *Ibid.*, **103**, 348.
Further investigations on the rôle of Bed-bugs in carrying relapsing fever.
Experiments on mice indicated that Bed-bugs do not spread relapsing fever.

ROSENHOLZ, H. P. and OVSYANNIKOVA, O. V. (1928): *Zh. eksperim Biol. Med.*, **10**, 180.

——— (1929): *Zbl. Bakt.* (*Abt. Orig.*) **110**, 160.
Bed-bugs fed on animals suffering from anthrax do not infect other animals.

ROW, R. (1922): *Ind. J. Med. Res.*, **10**, 476.
The transmission of *L. donovani.*

SAMBON, L. W. (1928): *Ann. Trop. Med. Parasit.*, **22**, 67.
Chicken-pox and Bed-bugs.

SCORDO, F. (1913): *Malaria Mal. Paesi caldi,* **4**, 20.
Kala-azar.

SELWYN-CLARKE, P. S., LE FANU, G. H. and INGRAM, A. (1923): *Ann. Trop. Med. Parasit.*, **17**, 389.
Bed-bugs do not transmit relapsing fever in the Gold Coast.

SHORT, H. E. (1923): *Ind. J. Med. Res.*, **10**, 721.
Herpetomonas ctenocephali, Fantham.

SHORT, H. E., SMITH, R. C. A. and SWAMINATH, C. S. (1932): *Ind. Med. Res. Mem.*, **25**, 103.
Kala-azar.

SHORT, H. E. and SWAMINATH, C. S. (1924): *Ind. J. Med. Res.*, **12**, 435.
Herpetomonas donovani.

SINTON, J. A. (1921): *Ind. Med. Gaz.*, **56**, 241.
Relapsing fever.

SKELTON, D. S. and PARHAM, J. G. (1913): *R.A.M.C. Jl.*, **20**, 291.
Found no conclusive evidence that the Bed-bug carries leprosy.

SMITH, A. J. and RIVAS, D. (1914): *Amer. J. Trop. Dis.*, **2**, 361.
Filaria.

THOMSON, D. (1913): *Brit. Med. J.*, **2**, 849.

——— (1914): *Ann. Trop. Med. Parasit.*, **8**, 19.
Bed-bugs and leprosy.

TOWNSEND, C. H. T. (1913): *Bull. Ent. Res.*, **4**, 125.
Bed-bugs do not transmit verruga.

TULLIDGE, E. K. (1916): *N.Y. Med. J.*, **103**, 1,167.
Typhus.

WENYON, C. M. (1912): *J. Lond. Sch. Trop. Med.*, **2**, 13.
Leishmaniasis, kala-azar and oriental sore are not transmitted by Bed-bugs but the flagellates are occasionally found in *Cimex lectularius*.

——— (1928): *Brit. Med. J.*, **2**, 558 (from *Rev. Appl. Ent.*).
Bed-bugs do not transmit kala-azar.

WIESE, O. (1918): *Deuts. med. Wschr.*, **44**, 60.
Lice carry relapsing fever, Bed-bugs do not.

WOODCOCK, H. M. (1923): *R.A.M.C. Jl.*, **40**, 81, 241.
Rickettsia bodies.

WRIGHT, W. (1916): *J. State Med.*, **24**, 380.
(from *Rev. Appl. Ent.*).
Quotes Dr. Y. T. Verjbitski of Petrograd to the effect that in linen or other fabrics soiled by crushed fleas, Bed-bugs, or their fæces, plague microbes can, under favourable conditions, remain alive and virulent for more than 5 months.

WU, LIEN-TEH, POLLITZER, R., LIN, CHIA-SWEE and JETTMAR, H. M. (1929): *Nat. Med. J. China*, **15**, 273.
Plague.

YAKIMOFF, W. L. (1915): *Bull. Soc. Path. exotique*, **8**, 474.
Negative results with Leishmaniasis in Bed-bugs.

YOUNG, C. W. and HERTIG, M. (1927): *Trans.* [*7th Cong.*] *Far-East Ass. Trop. Med.*, **3**, 19.
Kala-azar in N. China.

——— (1929): *Amer. J. Hyg.*, **9**, 227.
Kala-azar.

METHODS OF CONTROL.

ABBATUCCI, S. and ROUBAUD, E. (1926): *Bull. Soc. Path. exotique*, **19**, 901.
Used "Flit" against Bed-bugs and other insects; effective on contact; paraffin and pyrethrum basis.

Agriculture of Siberia, Tomsk (1916): No. 9–10, p. 210.
Castor oil against Bed-bugs.

ALDERSON, A. F. (1933): *R.A.M.C. Jl.*, **60**, 374.
Lethal action of steam and formalin vapour on Bed-bugs.

Ann. Rep. Tech. Serv. Dept. Agric. Haiti (1928–29), *Bull.* **17**, 157.
Bed-bugs were effectively dealt with by calcium cyanide dust spread on paper on the floor at a rate of 2 lb. per 100 c. ft.

Back, E. A. and Cotton, R. C. (1932): *Fmrs.' Bull. Wash.*, No. 1,670.
A complete and detailed description of all the cyanide processes in use at the present time in the United States of America, the methods employed and the precautions to be taken.

Bacot, A. W. (1914): *J. Hyg. Camb.* (*Plague Suppl.*), **3**, 665.
Experiments on the relative toxicity to Bed-bugs of vapours of phenol, formaldehyde, benzene, paraffin, naphthalene and camphor. Phenol was by far the most toxic.

Beatty, M. C. (1926): *R.A.M.C. Jl.*, **47**, 59.
Describes the fumigation of several barracks at Weisbaden by the Zyklon B. method, and states that it was in every way satisfactory. The penetration of the gas at a concentration of 1 per cent. reached Bed-bugs even in the smallest cracks. The method is stated to be costly.

Bertrand, G., Brocq-Rousseau and Dassonville, (1919): *C.R. Acad. Sci. Paris*, **169**, 441 (from *Rev. Appl. Ent.*).
Used chloropicrin gas with success against Bed-bugs, $\frac{1}{6}$ oz. to $\frac{1}{3}$ oz. to 36 c. ft. Fumigation should be repeated after 14 days.

Blacklock, B. (1912): *Ann. Trop. Med. Parasit.*, **6**, 415.
The resistance of *C. lectularius* to various reagents, powders, liquids and gases. Experiments with powders were carried out in five ways. (1) Bed-bugs sprinkled with powder; (2) Dish sprinkled with powder and Bed-bugs then introduced; (3) A ring of powder in the centre of which Bed-bugs were placed; (4) A mound of powder in the centre of the petri dish and the Bed-bugs placed round the sides; (5) Same as 4 with the addition of blotting-paper shelters for the Bed-bugs. Eggs were also used in the experiments. They were placed on the powder or sprinkled with powder and left for 1 hour, then cleaned. In neither case was the powder effective. A wide variety of powders were tried including a number of proprietary insect powders. A varying degree of success was obtained with the latter. Factors of consequence are fine sub-division of powder, dryness and lightness. French chalk and Dalmatian flowers were effective by methods 1 and 2. Pulv. chinchonae quickly makes Bed-bugs incapable of progression. In general powders are not practical as a remedy. Immersion in cold water for 24 hours killed Bed-bugs in 10 experiments, for 17 hours killed 22 out of 30. Boiling water was at once fatal. Water at 70° C. was fatal in 1 minute. Immersed for 1 minute in water at 60° C. 9 out of 10 recovered, and at 40° C. 17 out of 20. A 5 per cent. carbolic acid solution killed insects immersed in it in 10 minutes. In 5 minutes 9 out of 10, in 2 minutes 9 out of 20 were killed. In a 10 per cent. solution all were killed in 2 minutes. Perchloride of mercury was not satisfactory; 1 : 1000 solution failed to kill in $5\frac{1}{2}$ hours; 1 : 200 solution killed 13 out of 20 after immersion for 30 minutes. Paraffin killed all Bed-bugs after 5 seconds immersion. Bed-bugs can walk unharmed over wood-work treated with paraffin. Chloroform vapour immobilizes Bed-bugs temporarily. Exposure for 3 hours is necessary for a complete kill. Exposure to paraffin vapour for 18 hours had little effect. CO_2 was ineffective. Fifteen minutes exposure to coal gas was fatal in all cases.
The paper does not give full details as to the conditions under which these experiments were carried out.

Bogdandy, St. V. (1927): *Naturwissenschaften*, **15**, 474.
Bean leaves used in Balkans as a trap for Bed-bugs.

Brooke, G. E. (1915): *Lancet, Lond.*, **189**, 571.
Contact insecticide in Singapore:—Carbon bisulphide 1, Kerosene 20, mix by shaking, then add "Sanitas-sypol" 7, and keep in a stoppered bottle for use. Make 10 per cent. solution in water adding the water to the stock and not *vice versa*. Solution is milk white. It is best made up just before use as it deteriorates.

Brown, E. W. (1933): *U.S. Nav. Med. Bull.*, No. 3.
An investigation on the use of ethylene oxide for destroying Bed-bugs and cockroaches on ships. The experiments were carried out with "Carboxide," the trade name applied to a mixture of ethylene oxide and carbon dioxide, sold commercially in liquid form compressed in cylinders in the ratio of one part of ethylene oxide to nine parts of carbon dioxide by weight. 10 lb. of Carboxide contain 1 lb. of ethylene oxide by weight, but the insecticidal results of 10 lb. of the mixture correspond roughly to 2 lb. of ethylene oxide, apparently as a result of acceleration of respiration. With Bed-bugs the action was often delayed and specimens apparently unaffected at the end of an experimental exposure were dead the next day. The adult cockroach is not more resistant to the gas than the Bed-bug, but owing to the protective shell the eggs of the cockroach are more resistant and a second fumigation at the end of 10 days may be required to destroy newly hatched insects. For destroying Bed-bugs and cockroaches in relatively air-tight spaces the following minimum concentrations per 1,000 c. ft. are recommended:—5 lb. for 3 hours, 3 lb. for 6 to 12 hours and 2 lb. for 12 to 24 hours.
The author was unable to study adequately the minimum time-concentration dosage of Carboxide necessary to destroy the eggs of the Bed-bug. He quotes, however, a personal communication from Dr. E. A. Back, of the Bureau of Entomology, United States Department of Agriculture, in which the opinion is expressed, "that a "dosage of 8.8 oz. of ethylene oxide per 1,000 c. ft. with a 3-hour "exposure, was lethal to Bed-bug eggs and to the various stages of "the adult. This dosage would be equivalent to 2.7 lb. of Carboxide "per 1,000 c. ft."

Brug, S. L. and Van Slooten, J. (1927): *Mededeelingen van der Dienst der Volksgezondheid in Nederlandsch-indië*, **16**, 524.
Spraying with kerosene containing 7 per cent. of carbon tetrachloride and 3½ per cent. of methyl salicylate failed to kill Bed-bugs in a native bamboo bed.

Cameron, J. (1923): *China. Med. [Miss.] J.*, **37**, 689.
Found that a 5 per cent. solution of mercuric chloride ($HgCl_2$) in 90 per cent. alcohol completely destroyed Bed-bugs in bedsteads.

Canalis, P. (1916): *Bull. Off. int. Hyg. publ.*, **8**, 457.
Clayton gas.

Castellani, A. and Jackson, T. W. (1915): *J. Trop. Med.*, **18**, 253.
Kerosene oil was the best insecticide tried against Bed-bugs, then guaiacol. Pyrethrum was more effective against Bed-bugs than against lice. Sulphur fumigation was also tried.

Cooley, R. A. (1914): *Bull. Montana Agric. Expt. Sta.*, No. 102, p. 197.
Two applications of cyanide were needed to control a severe infestation of Bed-bugs.

Corlette, C. E. (1916): *Med. J. Aust.*, **1**, 391.
The use of cyanide against Bed-bugs.

CREEL, R. H. and FAGET, F. M. (1916): *Publ. Hlth. Rep. Wash.* No. 31, p. 1,464.
Suggest that HCN should be used as a routine fumigant.

CRIDDLE, N. (1923): *Nat. canad.*, **37**, 52.
Recommends superheating rooms to a temperature of 125° to 145° F. for at least 6 hours to exterminate Bed-bugs and other insects.

DE BRUYNE, M. F. (1933): *Technisch Maandblad voor Gemeentereiniging, Vervoerwezen en Ontsmetting*, No. 1, 2, 3 and 4. Fumigation with "Etox."
A concentration of about 2½ per cent. by volume and an exposure of from 8 to 10 hours gives good results on insects in houses which are suitable for gassing. In houses of poor construction, where the gas has many opportunities for escape, higher concentrations must be used, and it is useless to fumigate such buildings if there is any wind. There is no advantage in prolonging the exposure beyond 10 hours, since if there is leakage the gas dissipates, whilst if the building is gas-tight there is so much absorption by the walls, etc., that the concentration becomes too low to be effective. Special attention must be paid to attic rooms, which often harbour Bed-bugs and yet are seldom gas-tight. Fumigation may, in certain circumstances, be successfully carried out at low temperatures, but warmth is preferable owing to the activity of insects, etc. At low temperatures absorption is greater and difficulties arise with ventilation, especially if there is much moisture in the air.
With a concentration of 2½ per cent. for fumigation of houses, the cost of the materials is 50 per cent. higher than the cost of Zyklon B. On the other hand, fewer personnel are necessary and the costs of labour are less. On the whole, the process is more expensive and the results are not so reliable as with HCN. In spite of these drawbacks, the use of this fumigant should be considered where the surroundings are such that HCN cannot be used with safety. At Rotterdam both gases have been used on the same premises.

DE MELLO, F. and PARRAS, A. (1918): *Arq. Hig. Patol. Exot.*, **6**, 71.
A layer of hay 2 inches deep was burnt on the mud floors of infested dwellings in Goa and produced a temperature of over 100° C. to a height of 13ft. All Bed-bugs were killed.

DRYENSKI, P. (1928): *Trav. Soc. bulg. Sci. nat.*, **13**, 63. (In Bulgarian.)
Bionomics and methods of control of Bed-bugs.

FILIPPINI, A. (1921): *Ann. Igi.* [*sper.*], **31**, 419.
HCN.

FLETCHER, T. BAINBRIGGE. (1919–20): *Sci. Rep. Agric. Res. Inst. Pusa*, p. 95
Exposure to 52° C. for 2 minutes was fatal to Bed-bugs.

FROGGATT, W. W. (1919): *Agric. Gaz. N.S.W.*, **30**, 828.
Method of fumigating with HCN described.

GAL'KOV, V. P. (1926): *Défense des Plantes*, **3**, 98.
An experiment with HCN against Bed-bugs and cockroaches.

——— (1927): *Ibid.*, **4**, 531.
Defends the use of HCN.

GIBSON, A. (1918): *Agric. Gaz. Can.*, **3**, 949.
Describes the use of two plasterers stoves to superheat a four-roomed house. Temperatures ranging from 145° F. to 180° F. were maintained for about 7 hours; no sign of life was seen subsequently.

HARNED, R. W. and ALLEN, H. W. (1925): *J. Econ. Ent.*, **18**, 320.
An experiment in controlling Bed-bugs by superheating in the dormitories of the Agric. and Mechan. Coll., Mississippi. The outside day temperature at the time was about 89° F. to 90° F. Room

temperatures were raised to a maximum of about 120° F. by steam radiators and treatment lasted 2 days. Lower temperatures for a longer period were also fairly effective. A few live Bed-bugs were found afterwards but later inspections showed no further sign of infestation.

HASE, A. (1918): *Z. angew. Ent.*, **4**, 297.
Fumigation of houses with HCN for Bed-bugs using a 1 per cent. concentration for 24 hours. With expert care HCN fumigation can be undertaken safely and effectively in densely populated areas.

——— (1919): *Verh. deuts. Ges. angew. Ent.* [2. *Mitgliederversammlung*], p. 88.
Fumigation with HCN has been proved uniformly successful with Bed-bugs. A concentration of 1 per cent. by volume and an exposure of 4 to 6 hours, or longer if possible, is recommended.

——— (1932): *Zeitschrift für Parasitenkunde*, **4**, 369.
Ethylene oxide at a strength of 19.2 grammes per cubic metre (1 per cent. by volume) is more toxic to *C. rotundatus* than to *C. lectularius*. This concentration is not sufficient to kill all Bed-bugs and their eggs. Death is delayed for perhaps 24 hours. Bed-bugs in the third or fourth stages are more resistant than the adult insect.

——— (1932): *Arb. biol. Anst. (Abt.) Berl.*, **20**, 101.
Further experiments on ethylene oxide. It diffuses well. 60 g. per c.m. (3 per cent. by vol.) for 8 hours, or 50 g. for 24 hours, kills all Bed-bugs and eggs. Lethal effect is often delayed.

HÉRAUD, A. (1916): *La Vie Agric. et Rur. Paris*, **6**, 296.
Corrugated paper under a mattress is a successful trap, as Bed-bugs tend to lay and to hide in the crevices. The paper can be removed and burnt.

HEWITT, C. G. (1917): *Rep. Dept. Agric. Can.* [*Ent.*],
Endeavours are being made to substitute the superheating method of vermin destruction in place of cyanide.

HOSSACK, W. C. (1915): *Ind. J. Med. Res.*, **2**, 791.
A description of the Clayton process of disinfection of ships which kills, *inter alia*, Bed-bugs. He also discusses other methods some of which are ineffective.

HOWARD, L. O. (1916): *Fmrs'. Bull. Wash.*, No. 699.
An account of the hydrocyanic acid process of fumigation. This bulletin has however been superseded by Bull. No. 1670 by E. A. Back and R. T. Cotton.

JAMESON, G. D. (1933): *R.A.M.C. Jl.*, **60**, 138.
Advocates the use of the red house ant, *Monomorium pharaonis*, to eradicate Bed-bugs, and gives two instances in Gibraltar of their use, only one of which was successful.

KELSALL, A., SPITTAL, J. P., GORHAM, R. P. and WALKER, G. P. (1925) 56*th Annu. Rep. Ent. Soc. Ont.*, p. 24
Derris as an insecticide.

KEMPER, H. (1929): *Z. Desinfekt.*, **21**, 172.
Describes an apparatus for disinfestation by superheated steam. Successful only if care is taken to direct the steam jet into all possible harbourages.

KUHN, H. A. (1923): *J. Econ. Ent.*, **16**, 323.
A description of the use of various cyanide compounds.

LÉCAILLON, —. and AUDIGÉ, —. (1921): *Ann. Epiphytes*, **8**, 19.
Toluene was used on a wooden bedstead infested with Bed-bugs with complete success.

LISTON, W. G. (1917): *Rep. Bact. Lab. Bombay* [1915–1916].

——— (1920): *Ind. J. Med. Res.*, 7, 778.
Fumigation with HCN.

LUTRARIO, A. (1920): *Bull. Off. int. Hyg. publ.*, **12**, 484 (from *Rev. Appl. Ent.*).
Describes HCN method; chloropicrin and phosgene were unsatisfactory.

McDANIEL, E. (1926): *Mich. Agric. Expt. Sta. Circ. Bull.*, No. 94.
A popular account of the Bed-bug; advocates the use of sulphur, kerosene, and pyrethrum as remedies.

MARLATT, C. L. (1916): *Fmrs'. Bull. Wash.*, No. 754.
Life history, habits and methods of dealing with Bed-bugs. Fumigation preferable to spraying. Fumigation with HCN most effective of all. SO_2 effective (2 lb. sulphur per 1,000 c. ft.). Insect powders, formaldehyde and vapours of benzene, naphthalene, or camphor of little value. Benzene, kerosene, corrosive sublimate solution and turpentine applied with small brushes, feathers or sprayers, are useful. HCN and SO_2 kill all stages of Bed-bugs and their eggs.
R. H. Pettit recommends the following insecticide:—400 g. of pyrethrum are thoroughly extracted with 2,000 ml. of alcohol. To the filtered liquid are added 50 g. camphor, 150 ml. of cedarwood oil, 25 g. of citronella oil and 25 g. of lavender oil. The solution is sprayed from an atomiser of one pint or more capacity actuated by a piston instead of a rubber bulb. A second spraying should be given after two weeks. An average sleeping room requires 8 to 10 oz. of the liquid. The odour remains some little time in the room, but is not disagreeable. This procedure is uniformly successful.

NEWSTEAD, R., EVANS, A. M. and POTTS, W. H. (1925): *Ann. Trop. Med. Parasit.*, **19**, 91.
0.2 per cent. hydrogen cyanide in air does not, even if allowed to act for 3 hours, kill every Bed-bug. 0.3 per cent. of the gas acting for 1 hour is not sufficient to kill every Bed-bug. 0.3 per cent. of the gas, acting for 3 hours, will kill all Bed-bugs present, except where they can retire behind tongued and grooved boarding. Eggs of Bed-bugs are not more resistant to hydrogen cyanide than are the adults. Spraying with liquid hydrogen cyanide gives better results than does the dumping method, in that it tends to give more uniform concentration throughout the area. It is recommended, (1) That a concentration of 0.3 per cent. of hydrogen cyanide acting for a period of 3 hours should be used; (2) That where match boarding is present one or two boards should, if possible, be removed, in order to allow the gas easy access into the cavity behind. These experiments were designed primarily to deal with infestations of Bed-bugs in ships.

PARKER, T. (1923): *Bull. Bur. Biotech. Leeds*, **2**, 91.
A description of the use of "Fumesco" against Bed-bugs. It was not completely effective.

PHELPS, J. R. (1924): *U.S. Nav. Med. Bull.*, **20**, 247.
Vermin destruction on ships.

Public Health Rep. Wash. (1919), **34**, 2,713.
A bunk house was successfully freed from Bed-bugs by means of steam. The bunk house was a large wooden building of 70 rooms heated by steam pipes. The pipes were tapped in each room and pressure raised to between 80 to 100 lb. per sq. inch. The temperature was raised to about 160° F. in 2 hours and maintained for 3 hours. No signs of Bed-bugs were seen 2 months afterwards.

Public Health Rep. Wash. (1920) **35**, 2,964.
Virtually the same as Marlatt's paper.

PURDY, J. S. (1920): *Aust. Med. Cong.* [11*th Session*], p. 298 (from *Rev. Appl. Ent.*).
In one case where cockroaches had been exterminated in a house it was found advisable to re-introduce them to keep down Bed-bugs.

RANDIER, P. (1922): *Arch. Méd. Pharm. nav.*, **112**, 56 (from *Rev. Appl. Ent.*).
From results obtained in fumigating a Russian vessel of 16,000 tons, chloropicrin seems to be eminently suitable for naval conditions About 650 lb. of chloropicrin was used and a total destruction of cockroaches, fleas and Bed-bugs was effected.

REYNOLDS, D. (1925): *R.A.M.C. Jl.*, **45**, 48.
The formalin and chloride of lime method of disinfestation was successfully carried out in one case.

ROBERTS, N. and ROBERTSON, G. E. (1916): *U.S. Nav. Med. Bull.*, **10**, 296.
An account of the fumigation by hydrogen cyanide of the U.S.S. *Tennessee.* The sulphuric acid and sodium cyanide method was used.

ROSS, W. A. (1916): *Canad. Ent.*, **48**, 74.
A description of superheating to kill Bed-bugs. In 9 hours the temperature was raised in three different rooms to a maximum of 162° F., 140° F. and 158° F. respectively, after which it fell gradually. Outside temperature maximum 73° F. minimum 64° F. All stages of Bed-bugs killed.

SCHLICHTEGROL, —. (1917): *Münch. med. Wschr.*, **64**, 239.
A mixture of turpentine and spirits of salts recommended for use against Bed-bugs.

SCHLUPP, W. F. (1922): *J. Dept. Agric. S. Afr.*, **4**, 132.
Compares sulphur with cyanide. It is definitely less toxic to Bed-bugs partly because the evolution of gas is much slower. In certain cases, however, it has advantages over HCN (e.g., where expert supervision is not available) and if used in sufficient quantity may be very effective. In leaky rooms a large number of small doses is better than one large one.

SCOTT, E. W., ABBOTT, W. S. and DUDLEY, J. E., Jnr. (1918): *Bull. U.S. Dept. Agric.*, No. 707.
Experiments were carried out on Bed-bugs with a number of contact insecticides. Twenty Bed-bugs confined in a pint jar were thoroughly dusted or sprayed with the insecticide to be tested. The object was to find out whether the insecticides used would kill Bed-bugs, not to determine their value under practical conditions. Practically all Bed-bugs in the jars were killed by hydrocarbon oils of the kerosene type containing varying amounts of nitrobenzene, phenols, essential oils, etc. Petrol was not so good as the heavier oils and did not kill the eggs. Coal tar creosote emulsions were effective when used undiluted but not so good when diluted with water. Mercuric chloride was effective, but better in 6 per cent. than in 2 per cent. solution. Other liquids found effective were acetic acid (50 per cent.), strong ammonia solution, pine-needle oil, glycerine, turpentine and nicotine sulphate solution. Among powders pyrethrum, sabadilla seed and mercuric chloride were the best. Arsenious oxide, borax, phosphorus pastes, tobacco powder and hellebore were all ineffective.

SEMIKOZ, F. F., MALUISHEVA, A. I. and SHERISHORINA, S. I. (1927): *Rev. Microbiol. Epidémiol*, **6**, 72 (from *Rev. Appl. Ent.*).
The use of chloropicrin against Bed-bugs.

SMITH, R. C. (1926): *J. Econ. Ent.*, **19**, 65.
Experiments with calcium cyanide against household insects. Flake or granular calcium cyanide was spread on paper on the floor of the houses to be fumigated. Sometimes cardboard boxes were used and a pint of water added. The insects were usually killed but discolouration was noticed in paintwork, leather goods, etc., and nickel and silver articles were tarnished. The smell persisted for several days after fumigation and in some cases for a week or more.

STOCK, P. G. and MONIER-WILLIAMS, G. W. (1923): *Rep. Publ. Hlth. Med. Subj. Lond.*, No. 19.
A comprehensive Report on the use of hydrogen cyanide for fumigation purposes.

STOREY, G. (1916): *Agric. J. Egypt*, **5**, 81.
A description of the sodium cyanide-sulphuric acid method of fumigation in barracks. All wooden ceilings, floors and stairs should be forbidden in barracks in Egypt, and other woodwork reduced to a minimum. Bedsteads should contain as few cracks as possible.

STRAND, A. L. (1924): *Circ. Montana Agric. Exp. Sta.*, No. 123.
The sodium cyanide-sulphuric acid method.

TAFOOZOL, HOOSAIN. (1913): *Ind. Med. Gaz.*, **48**, 84.
An emulsion of turpentine and soapsuds in equal parts is very effective against Bed-bugs.

VIOLLE, H. (1926): *Hyg.-Rev.*, **48**, 502.
The sodium cyanide-sulphuric acid method of ship fumigation.

WAKELAND, C. (1932): *Ext. Circ. Idaho.*, No. 38.
Sodium cyanide-sulphuric acid method.

WALLACE, F. M. and OTHERS. (1920): *3rd Rep. Indiana Dept. Conserv.*, p. 37.

——— (1924): *6th Ibid.*, p. 28.
Advocates the use of gasoline against Bed-bugs.

WASHBURN, F. L. and HOWARD, C. W. (1917): *Circ. Minn. Ent.*, No. 44.
The usual remedies such as sulphur, etc., may be used, also a spray of corrosive sublimate 1 oz., alcohol ½ pint, turpentine ¼ pint. Special attention should be paid to cracks, etc., and two or more applications may be necessary at intervals of 2 weeks. Joints and cracks in bedsteads should be sprayed with equal parts of kerosene and turpentine, and the cracks filled with hard soap. As a temporary measure to clear a bed several wads of cotton wool should be saturated with oil of pennyroyal and placed on various parts of the mattress. Spirits of camphor rubbed on the body just before retiring will keep fleas away and might be useful against Bed-bugs.

WIBAUT-ISEBREE MOENS, N. L. (1925): *Ned. Tijdschr. Geneesk*, **69**, 627.
Infestation of dwellings by *Cimex columbarius*.

WILLIAMSON, M. J. (1914): *R.A.M.C. Jl.*, **23**, 623.
A description of the technique of the cyanide fumigation process as applied to barracks. 10 oz. of potassium cyanide with the appropriate amount of sulphuric acid recommended for 1,000 c. ft., i.e., a nominal concentration of 1 in 300, with an exposure of not less than 4 hours. An important point is that sealing up should be done from the outside so as to avoid closing Bed-bug harbourages and thus preventing access of the gas.
It was not found possible to eradicate Bed-bugs by scrubbing the barracks and furniture with cresol solution, and paraffin.

MISCELLANEOUS.

ADERS, W. M. (1913): *Zanzibar Protectorate, Med. and Sanit. Rept.* p. 76.
Presence of the Bed-bug in Zanzibar.

BLATCHLEY, W. S. (1928): *Florida Ent.*, **12,** 43.
Differentiates between *C. lectularius* and *Haematosiphon inodorus* Dug.

BODENHEIMER, F. S. (1924): *Zbl. Bakt.*, [*Abt. Orig.*], **93,** 474.
Curves showing rate of development of various insects (including Bed-bugs) at different temperatures.

CHEVALIER, L. (1929): *Bull. Soc. Sci. nat. méd. Seine-et-Oise,* **10,** 46.
Animals that prey on the Bed-bug.

FLINT, W. P. (1922): *Circ. Illinois Agric. Expt. Sta.* No. 257.
Gives a short life history and the usual remedies. HCN and sulphur as fumigants, kerosene and mercuric chloride as contact insecticides.

GIRAULT, A. A. (1907): *Zool. Ann.*, **2,** 143.
A bibliography of the Bed-bug *Cimex lectularius* L. up to the year 1906.

LORANDO, N. T. (1929): *Sci. Mon.* [N.Y.], **29,** 265 (from *Rev. Appl. Ent.*).
In Greece a spider *Thanatos flavidus* Simon preys upon *Cimex*, 30 to 40 Bed-bugs being eaten daily. Small spiders start feeding at once.

MALLY, C. W. (1920): *S. Afr. J. Sci. Johannesburg,* **17,** 64.
Independent of any transmission of disease . . . the Bed-bug deserves special attention on account of its influence on the efficiency of labour.

MOTE, D. C. (1917): *Bull. Ohio Agric. Expt. Sta.*, No. 320, p. 139.
C. lectularius has been found to infest chicken coops in various parts of the State.

ROUBAND, E. and WEISS, A. (1927): *Arch. Inst. Pasteur Tunis,* **16,** 81.
Ploiaria domestica, Scott, preys on Bed-bugs in Tunis.

South Africa. (1922): *J. Dept. Agric.*, **4,** 209.
Cimex pilosellus, the Bat-bug, is not likely to be a regular parasite of man.

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